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OCEAN STEAMERS WITH STEAM TURBINES.

Although the development of the steam turbine for marine propulsion has well within a period of four or five years, there are already in service a large number of turbine-propelled ocean and coasting steamers. These include three large and fast transatlantic steamers, while two more which are now being built for this service will be by far the largest and most powerful steamships ever built. The development of the turbine steamer is discussed in another column, and in the present article we give some description of the five transatlantic steamers above mentioned.

ALLAN LINE STEAMERS.

A few years ago the Allan Line Steamship Co. decided to add larger and faster vessels to its principal transatlantic line of passenger steamers running between Montreal and Liverpool, and it took the bold step of adopting steam turbines for its two new ships, although up to that time no regular ocean-going steamers had been equipped with this system of propulsion. These two vessels are therefore notable in themselves, and as the pioneers in the introduction of steam turbines for ocean service. They are practically identical, but were built by two different firms, and so embody certain features representing the ideas of their respective builders. The "Victorian" was built by Workman, Clark & Co., of Belfast, Ireland, and was launched Aug. 25, 1904. The original intention was to equip it with reciprocating engines and twin screws, and the turbines and triple screws were only decided upon after the hull had been commenced. The same firm also built the Parsons turbines with which the ship is equipped. The "Virginian" was built by Alex. Stephen & Son, of Linthouse, Glasgow, Scotland, and was launched on Dec. 22, 1904. Its turbines were built by the Parsons Marine Steam Turbine Co. Fig. 1 is a view of the "Virginian" and Fig. 2 is a view within the engine room.

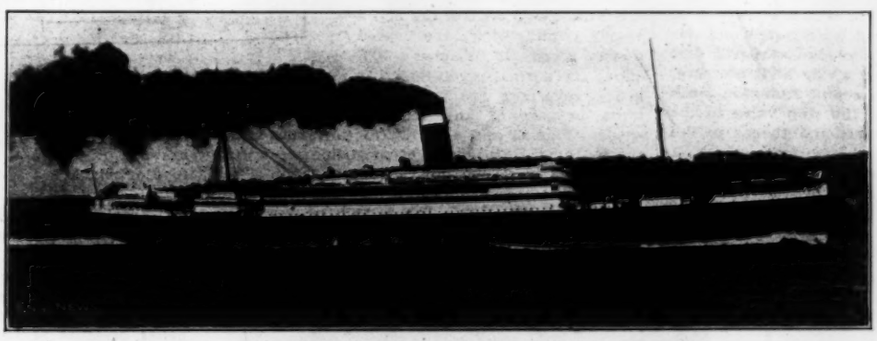


FIG. 1. TURBINE STEAMER "VIRGINIAN," OF THE ALLAN LINE: (MONTREAL AND LIVERPOOL).

The following description applies to both steamers. The hull is divided by transverse bulkheads, into eleven compartments, so that with the subdivision of the double bottom there are 20 watertight compartments. Instead of the usual arrangement of posts or stanchions supporting the deck beams, self-supporting deck girders are largely used, thus making the hold available to better advantage for the stowing of cargo. There is a raised forecastle and a raised poop, while at the middle is a long deck-house or superstructure carrying the saloon and promenade decks. Cold storage chambers and a refrigerating plant are provided, and there are ten steam hoists and derricks for handling the cargo.

There are three turbines and screws. In the center line of the hull is the high-pressure turbine, driving a screw directly behind the rudder. On either side is a low-pressure turbine, driving a screw some distance forward of the central screw. The screws first fitted were four-bladed and 9½ ft. diameter. These were found to be too large, reducing the number of revolutions to such an extent as to prevent the turbines from doing their full work. The new propellers are 8½ ft. in diameter, with three blades. At the after end of each low-pressure turbine is a reversing turbine for driving the ship astern, and these are operated independently, thus greatly facilitating the manoeuvering of the ship, as with twin screws. The reversing turbines are of considerable power, but run idle when the ship is going ahead, being of course keyed upon the same shaft as the main turbines. Steam is supplied by nine single-ended Scotch boilers (eight in the "Victorian"), carrying 180 lbs. pressure and working under forced draft. In a paper presented by Mr. J. H. Biles before the British Association for the Advancement of Science (Engineering News, Oct. 26, 1905), it was stated that the use of turbines instead of reciprocating engines in these steamers saved a space available for 60 passengers and a weight of 400 tons in machinery.

The turbines are intended to run at about 300 r. p. m. for full speed, which was designed to be 17 knots or nautical miles per hour in sea service. The "Victorian" on its trial trip made 19.5 knots with the turbines running at 260 revolutions and developing about 12,000 HP.; the "Virginian" developed about 12,500 HP., and a speed of 19.75 to 19.8 knots, with the turbines running at 280 revolutions. This turbine speed, however, was lower than intended, and it was considered that with propellers of smaller diameter and finer pitch the speed of revolution could be greatly increased and the available steam used to better advantage. After a few voyages these changes were made, as already noted. The second voyage of the "Virginian," in July, 1905, was made from Moville (Ireland) to the Canadian mail station at Rimouski in 6 days, 3 hours; the steamer averaged 17.05 knots per hour and made from 380 to 420 knots per day. In August, 1905, the same steamer made the fastest run on record between Moville and Belle Isle, 1,700 miles, the average sea speed being about 17 knots, but on two trips in May and June, 1906, it averaged a speed of 17½ knots, with a very moderate coal consumption. The consumption is said to be practically the same as for triple-expansion marine engines of the most modern type. The principal dimensions and particulars of these steamers are given in the accompanying table.

CUNARD LINE STEAMERS.

The Cunard Steamship Co. first considered the use of steam turbines in September, 1903, when negotiations were being made with the British government in regard to the construction of two large and powerful mail steamers which would be designed to serve as cruisers when required by the government. At that time the company appointed an engineering commission to investigate the matter, and its report was made in 1904. In December, 1903, however, before any definite action had been taken in regard to these particular vessels, proposals were received for the construction of a duplicate of the large but moderate-speed steamer "Caronia," built in 1903. The great shipbuilding firm of John Brown & Co., of Clydebank (Glasgow), Scotland, then made a proposition to build this vessel and to use triple screws driven by Parsons steam turbines. This was accepted, and the contract for the turbine steamer "Carmania" was awarded early in 1904. It may be noted, also, that the turbines and all machinery were built by the shipbuilding firm. The keel was laid on May 17, 1904, and the vessel was launched in March, 1905.

The hull construction includes a flat keel plate with internal keel, the latter being a plate girder 5 ft. deep. On either side of this are other longitudinal girders; these with the transverse girders and the floor and skin plating form the double bottom, which is utilized for water ballast. The main frames are 9-in. steel channels, 32 ins. apart in the central portion, while for the bow and stern portions they are heavy angles spaced 27 ins. apart. Every fifth frame in the engine and boiler compartments, and every sixth frame beyond these, is a plate girder 30 ins. deep, and between these are longitudinal plate-girder stringers with the webs horizontal. The skin or shell plates are mainly 5 ft. wide and 1 in. thick, and in assembling them they were gripped together and to the frames by hydraulic power, so that the service bolting would make the work

as tight as possible. Hydraulic riveters of both the scissors and bow types were used for the greater part of the work; the former had a gap of 5 ft. to 6 ft. 3 ins., and the latter had a gap of 4 ft. 4 ins. to 5 ft. 9 ins. The hull is divided into compartments by twelve bulkheads of ½-in. plate, stiffened by 10-in. channels 2½ ft. apart. The openings have doors operated on the Stone-Lloyd system, and can be operated independently by connections at the bulkheads, or simultaneously by apparatus controlled from the main bridge; in the latter case, any door can be held open long enough to enable men in the compartment to get out.

The deck beams are steel channels supported by columns or pillars of 3 ins. to 6½ ins. diameter. Where the beams are interrupted at openings for the machinery and boiler space, they are framed into heavy box girders. The deck plates are mainly ⅝-in. thick, or 1 in. at the sides of the ship. Besides the three shaft tunnels there is a tunnel for the steam and hydraulic pipes, electric cables, etc., which are thus always accessible for inspection and repair. Upon the floor or inner bottom are the boiler seats and heavy box girders to support the turbines. The stem is of forged steel, and the stern post and stern brackets are steel castings. The rudder is also of cast steel, in three parts, with an area of 270 sq. ft. There are eight decks, the upper one being 45 ft. above the water line. The promenade deck is 400 ft. long.

Before undertaking to build the turbines for this great steamer, John Brown & Co. built three 1,800-HP. turbines for experimental work, which was carried on for about six months. During this time tests were made with different numbers and forms of blades, and observations were made as to steam consumption, etc., under different conditions of working. The revolving centers of the turbines are of cast steel and the casings of forged steel. There are about 1,115,000 blades in all. To ensure accurate balance of the revolving portions, they were tested and adjusted while carried on knife-edge supports, and finally tested by being run under high pressure.

In regular working, the steam from the main steam pipe passes through the stop valve to the high-pressure central turbine, and thence to the two low-pressure wing turbines, from which it passes to the condensers, which are between the wing turbines and the sides of the hull. In manoeuvering or handling the ship, live steam can be admitted to either of the low-pressure turbines by means of valves operated by steam cylinders and controlled by hand levers. A large non-return valve closes the connection between the high-pressure and the two low-pressure turbines when the latter are taking live steam; this is operated by a steam and hydraulic engine controlled from the working platform, and if not closed before the live steam is admitted it will be automatically closed as soon as the pressure in the low-pressure turbines reaches a given limit; each of these turbines is then operated and controlled as an independent unit. The governors are adjusted to control the speed supply and bring the speed down when it reaches 10% above the normal revolutions per minute. Emergency governors are provided to stop the turbines in case of any serious increase in the speed. Figs. 3 and 4 show (to the same scale) the machinery equipment of the triple-screw turbine steamer "Carmania" and the twin-screw steamer "Caronia," these being sister ships or duplicates. The latter has a pair of quadruplé expansion reciprocating engines, with cylinders 39, 54½, 77 and 110 ins. diameter, and 66 ins. stroke; the connecting rods are 12 ft. long, and the engines are 36 ft. high above the bed plates.

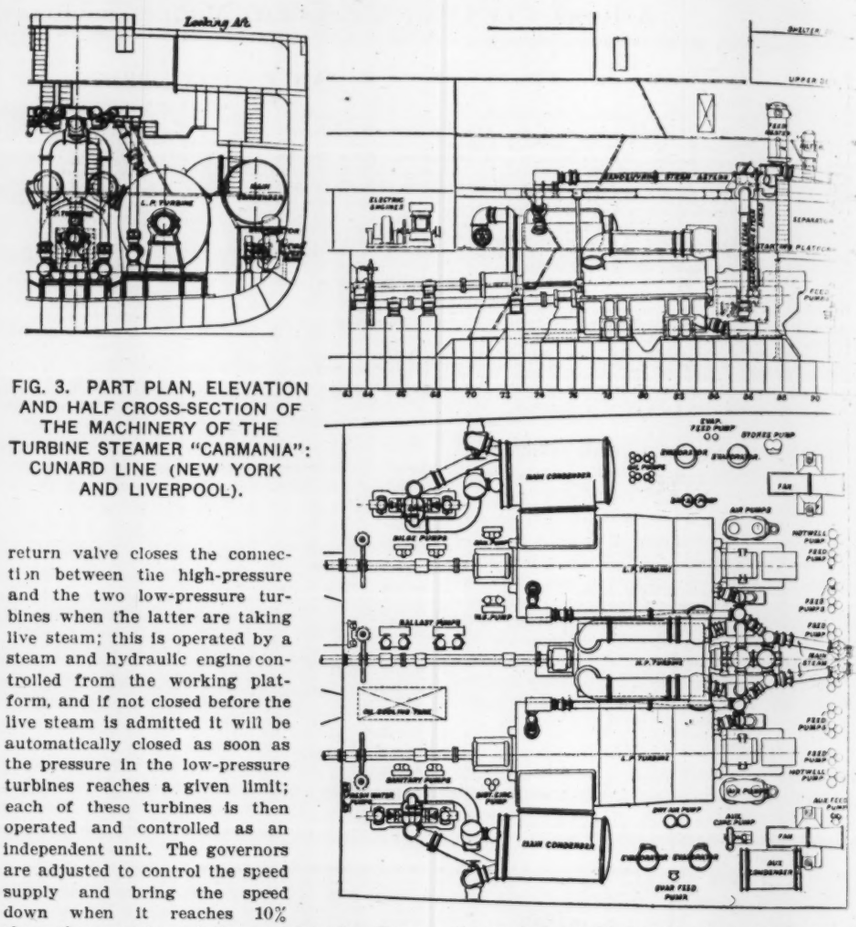
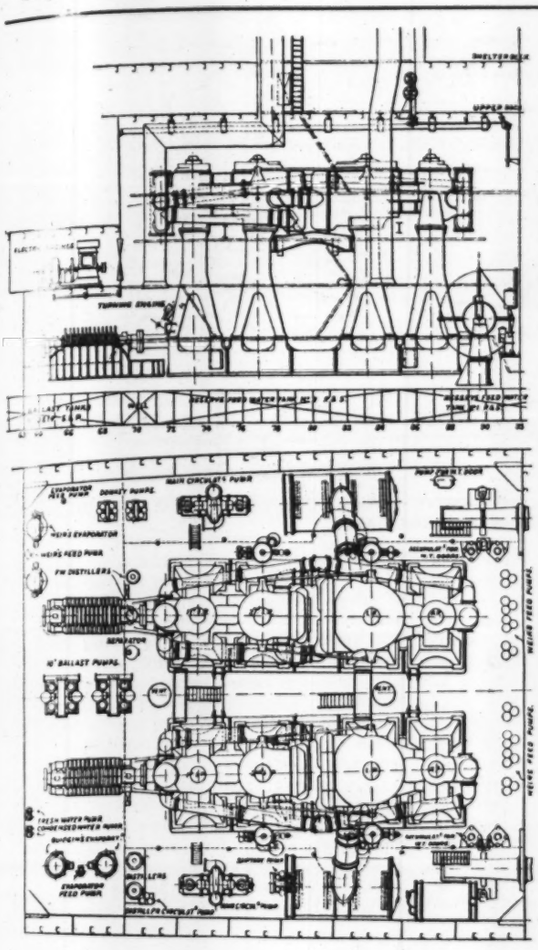


FIG. 3. PART PLAN, ELEVATION AND HALF CROSS-SECTION OF THE MACHINERY OF THE TURBINE STEAMER "CARMANIA": CUNARD LINE (NEW YORK AND LIVERPOOL).

Steam is supplied by eight double-end and five single-end Scotch boilers, arranged in two boiler rooms and working under the Howden hot-draft system. There are two oval smokestacks, the tops of which are 135 ft. above the grates. The boilers have 2.35 sq. ft. of heating surface per HP. (designed for 21,000 I. HP.), and develop 17.3 I. HP. per sq. ft. of grate area. The boiler pressure is 195 lbs., and the initial pressure at the high-pressure turbine is 180 lbs., reduced to 80 lbs. at the low-pressure turbine. In the sister ship "Caronia" (with reciprocating engines) the boiler pressure is 210 lbs., and the initial pressure in the high-pressure cylinder about 200 lbs. Both these steamers are economical in fuel, but the "Carmania" is said to be about 16% more economical than the other, while it attained a speed of 1 knot beyond that of the "Caronia" in the trial trip. The vacuum is maintained at 28 ins. by the Weir high-vacuum system, employing two twin air-pumps supplemented by two double dry-air pumps; these latter deal only with the air and vapor, and can be run at high speed so as to secure a large volume of displacement. The high-pressure turbine is 8 ft. in diameter, with three stages; the low-pressure turbines are 14 ft. in diameter and 36 ft. long, also with three stages. They drive 14-in. shafts with 14-ft. propellers, and run at about 180 revolutions.

Mention has already been made of two steamers of enormous size and power which were decided upon by the Cunard Line in 1904. These great steamers, which have been launched this year, mark an important development in marine engineering: they are by far the largest and most powerful steamers ever built, they are designed for the highest sustained sea speed, and they are propelled by four screws driven by steam turbines. These vessels have been named the "Lusitania" and "Mauritania;" the first is being built by John Brown & Co., of Clydebank (Glasgow), Scotland, and was launched on June 7. The other is being built by the firm of Swan & Hunter, Wigham, Richardson & Co., of Newcastle,

FIG. 2. THE ENGINE ROOM OF THE TURBINE STEAMER "VIRGINIAN."



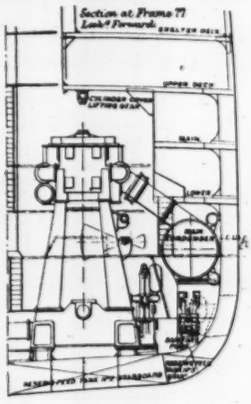


FIG. 4. PART PLAN, ELEVATION AND HALF CROSS-SECTION OF THE MACHINERY OF THE STEAMER "CARONIA": CUNARD LINE.
(This steamer is a duplicate of the "Carmania," but fitted with quadruple-expansion reciprocating engines.)

DIMENSIONS OF TRANSATLANTIC TURBINE STEAMERS.

Steamers	"Victorian" and "Virginian."	"Carmania."	"Lusitania" and "Mauritania."
Line	Allan.	Cunard.	Cunard.
No. of screws	3	3	4
Length	540 ft. 0 ins.	672 ft. 6 ins.	785 ft. 0 ins.
Beam	60 " 0 "	72 " 0 "	88 " 0 "
Depth	42 " 6 " [1]	52 " 0 "	60 " 8 "
Draft, loaded	29 " 6 "	33 " 0 "	33 " 0 "
Displacement	12,000 tons	30,918 tons	38,000 tons
Tonnage, gross	11,200 " [2]	20,000 "	32,500 "
Boilers, number	9 [3]	13	25
Heating surface	30,800 sq. ft.	.....	160,000 sq. ft.
Grate area	726 "	....	3,950 "
Boiler pressure	180 lbs.	195 lbs.	200 lbs.
Propellers, diam.	8 ft. 0 ins.	14 ft. 0 ins.	17 ft.
Propellers, number of blades	3	3	3
Turbines, h. press.			
Diameter	5 ft. 6 ins.	8 ft. 0 ins.	.....
Length	18 " 0 "	.....	.....
Weight	60 tons.	.....	.....
Turbines, l. press.			
Diameter	8 ft. 6 ins.	14 ft. 0 ins.	20 ft.
Length	25 " 0 "	36 " 0 "	....
Weight	100 tons	.....	430 tons
Revs. per minute	280 to 300	180	100
Shafts, diameter	12 ins.	14 ins.	22 ins.
I HP.	12,000 HP.	21,060 HP.	68,000 HP.
Speed	17 knots	20 knots	25 knots
Passengers	1650 [4]	2,600	2,300
Cargo	8,000 tons	10,000 tons	15,000 tons

[1], "Virginian", 41 ft. 2 ins.; [2], "Victorian", 10,630 tons; [3], "Victorian", 8; [4], "Victorian", 1,300.

England. Their main dimensions are given in the accompanying table. The four propellers are 17 ft. diameter, with three blades. The pitch is said to be about 14 ft., due to 2,533 ft. per min. advance of the vessel when making 182 r. p. m.

For the high sea-speed of 25 knots per hour a propelling plant of 66,000 HP. has been provided, and it was considered that this enormous power could best be distributed through four shafts and screws. The turbines are all on the Parsons compound system. The two high-pressure turbines are on the outer shafts, while on the inner shafts are the low-pressure turbines and the reversing turbines. Each low-pressure turbine weighs about 430 tons, and its rotating element has a diameter of 19 ft. 4 ins. over the blades, the maximum length of blade (at the exhaust end) being 22 ins. The peripheral speed will be about 142 ft. per sec., and the clearance between the fixed and rotating blades ranges from 1/50 in. at the inlet end to 1/25 in. at the exhaust end. The spindle of the turbine is 33 ins. in diameter, mounted on a 22-in. propeller shaft. All the shafts are enclosed within the hull, so that no outboard stern brackets are required.

The outer propellers are about 70 ft. forward of the inner ones, and 4 ft. above them; the circles described by the blades do not extend beyond the line of the maximum width of the hull or within the circles described by the blades of the inner propellers. These inner propellers are just behind the stern frame and rudder, and the keel is arched up at this point so as to give solid water between them; their blades do not overlap the center line. Beyond the propellers the keel is brought down again to carry the footstep bearing of the rudder; the rudder is of the balanced submerged type and weighs about 65 tons. All the propellers have three blades. Fig. 5 is a stern view of the "Lusitania" before launching and shows the positions of the propellers.

There are 25 boilers of the Scotch marine type, having 192 furnaces and being fitted with the Howden hot-draft system. They are arranged in four boiler rooms, each of which is served by an oval smokestack, 24 ft. in longitudinal diameter and with its top 155 ft. above the keel, or 120 ft. above the load water line. The working pressure is 200 lbs., and the ratio of heating surface to grate area is about 40 to 1. About 5,000 tons of coal will be required for each trip, the consumption being estimated at 1.45 lbs. per I. HP. per hour. In an article in "The Engineer," of London, the steam consumption is estimated at 15 lbs. per I. HP. hr., and the following figures are given to present some idea of this immense floating power plant:

The horse-power is not only the greatest ever put afloat, but the greatest ever concentrated in four engines running, as we may say, in partnership. If we take the consumption of the turbines at 15 lbs. of steam per HP. per hour, this gives for 65,000 HP. no less than 435 tons of steam per hour and probably not much less than 50 tons of coal in the same period, or, say, 1,200 tons per day of 24 hours. It is not remarkable that the engine and boiler room crews number 400 men. When we come to the consumption of air by the furnaces and of water for condensation we have figures yet more staggering. The centrifugal pumps must deliver about 22,000 tons of water per hour through the condensers; that is, to say, about 50 times the weight of steam, because the very high vacuum essential to economy with the turbine involves the use of enormous volumes of water. As for the air passing through the furnaces, that will weigh about 700 tons per hour. As 30,000 cu. ft. weigh a ton, not far from 21,000,000 cu. ft. of air will pass through the grates every 60 minutes.

The hull is built on the cellular double-bottom system, very much the same as in the "Carmania," already described, and the depth between the inner and outer bottom is about 5 ft. The shell plates are mainly in lengths of 40 ft., and weigh four or five tons each. The hull is divided into compartments by bulkheads, the openings in which are fitted with doors controlled by the Stone-Lloyd system above mentioned. The stem is of forged ingot steel, with a cast steel connection to the keel; the 50-ton stern frame and 30-ton propeller shaft brackets are of cast-steel. The weight as launched was 16,000 tons.

A STEAM RAILWAY MOTOR CAR has been built by the Chicago, Burlington & Quincy Ry. for experimental service. One end has a steam truck, with 42-in. wheels and cylinders 13 x 17 ins.; the piston valves are operated by a Walschaert valve gear. A vertical boiler is used, fitted with a superheater and burning oil fuel. At the rear end of the car is an ordinary car truck. Behind the engine room is a baggage compartment, and next to that is the main passenger compartment, seating 44 passengers.

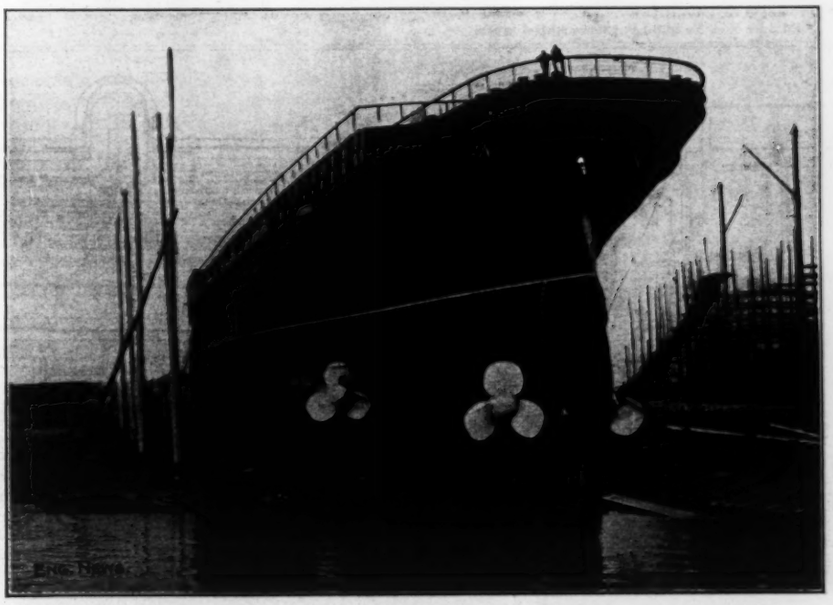


FIG. 5. STERN VIEW OF THE TURBINE STEAMER "LUSITANIA": CUNARD LINE.

BELGIAN AND FRENCH LOCOMOTIVES AT THE LIEGE EXHIBITION.

Among the special features of the exhibition held at Liege, Belgium, in 1905, were the railway exhibits, which comprised 33 locomotives and 58 cars, besides electric cars, locomotive trucks and railway appliances. Practically all of these were Belgian and French exhibits. The locomotives ranged from fast passenger and heavy freight engines to small engines (one being an electric storage battery locomotive) for mines and industrial works. They well represented the modern development of the locomotive in those countries, and were also representative of various firms, the 20 Belgian engines being by 12 different builders, and the 12 French engines by 8 builders. Of these 32 steam locomotives no less than 26 were tank engines, several of these being large passenger and freight engines, and including one of the great 102-ton 0-6-2-2-6-0 duplex engines of the Northern Railway of France, described in our issue of Dec. 21, 1905. Eight engines (all Belgian) had superheaters, the Schmidt superheater being used on six and the Cockerill on the other two. Two compounds and a four-cylinder simple engine were among those fitted with superheaters. Only three of the Belgian engines were compounds, but the five large French engines were compounds; all these were on the four-cylinder balanced system, with the exception of one French two-cylinder compound. There was one four-cylinder simple engine, noted above. Piston valves were used on 13 of the engines. Of the 19 tenders in the exhibits only four were of the American type with double trucks; 13 had six wheels, and two had four wheels. Of the 20 Belgian engines all were of standard gage, with the exception of a four-wheel industrial engine of 24 ins. gage. Of the 12 French engines eight were of standard gage, three of meter gage (including a ten-wheel engine for the Indo-China Railway), and one of 24 ins. gage.

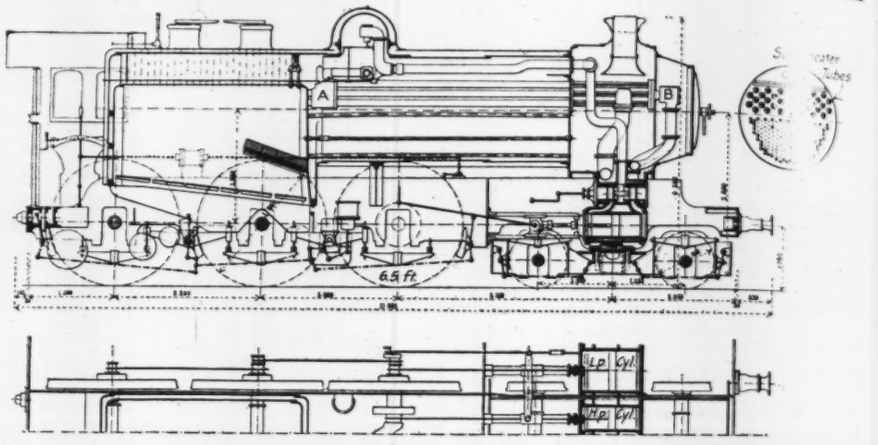


FIG. 1. TEN-WHEEL COMPOUND LOCOMOTIVE WITH COCKERILL SUPERHEATER; BELGIAN STATE RAILWAYS.

Particulars of some of the most interesting engines are given below, and their dimensions are given in the accompanying tables.

BELGIAN LOCOMOTIVES.

In Table No. 1 are given the leading dimensions of some of the Belgian engines of different types, and we give below some information as to these particular engines.

FOUR-COUPLED ENGINES.—Engine No. 1 in the table is a passenger engine of the 4-4-0 type, with inside cylinders, and is practically a reproduction of an English engine purchased for experiment. On the Belgian State Railways there are 140 engines of this class already in service, and others are under construction. They are designed to haul trains of 300 tons at an average speed of 50 miles an hour on lines of easy profile (maximum grades 0.5 to 0.6%). Two similar engines were exhibited, one being fitted with a Schmidt superheater, having three rows of tubes, six in a row, replacing 102 of the ordinary tubes. Each contains a U-tube for steam. The fire-box is deep, and the piston valves are operated by Stephenson link valve gear; the main piston rods are carried through the front cylinder heads, as in several of the other engines exhibited. A screw reversing gear is used, but a steam cylinder provides for rapid movement of the gear if necessary. The engine is fitted with a train-lighting apparatus consisting of a dynamo and a two-cylinder single-acting engine mounted on the fire-box. For suburban service these roads employ tank engines, No. 2, of the Atlantic type (4-4-2) with inside cylinders, and these are very similar to the engines above described. Engine No. 3 is a four-cylinder bal-

TABLE I.—TYPES OF BELGIAN LOCOMOTIVES AT THE LIEGE EXHIBITION.

	1	2	3	4	5	6	7	8	9
Railway	Belgian State Railways							Bel. Nor.	Bel. State.
Type	4-4-0	4-4-2 (tank)	4-4-2	0-6-0	4-6-0	4-6-0	4-6-0	4-6-0	0-3-0 (tank)
Comp. or simple	Simple.	Simple	Comp., 4-cyl.	Simple	Simple	Comp., 4-cyl.	Simple, 4-cyl.	Comp., 4-cyl.	Simple
Superheater	.....	Schmidt	.....	Schmidt	Schmidt	Cockerill	Schmidt	.....	.....
Cylinders, h. p., ins.	19.3 x 26.6	18.8 x 24.4	14.4 x 25.6	20 x 26.4	20.8 x 26.4	14.4 x 27.2	17.4 x 24.4	14 x 25.6	19.2 x 24
" l. p. "	.....	.....	24.0 x 25.6	.....	.....	24.8 x 27.2	.....	22 x 25.6	.....
Driving wheels	6.56 ft.	5.90 ft.	6.51 ft.	5.00 ft.	5.57 ft.	5.90	6.50 ft.	5.80	4.14
Boiler, diameter	4.65 "	4.34 "	4.88 "	4.65 "	5.25 "	5.30	5.30 "	4.50	4.46
" rail to c. line	8.00 "	8.05 "	8.85 "	8.30 "	8.69 "	9.18	9.18 "	8.00	7.60
Tubes, No. and diameter	265 — 1.60	132 — 1.60	*139 — 2.8	154 — 1.60	168 — 1.8	219 — 1.8	1,80 — 1.8	107 — 2.8	264 — 1.6
Superheat tubes, "	.....	15 — 0.47	.....	18 — 0.47	21 — 0.47	30 — 0.4	25 — 0.4	.....	.....
Tubes, length	11.64 ft.	10.50 ft.	14.43 ft.	14.50 ft.	13.54 ft.	13.12 ft.	13.12 ft.	14.0 ft.	11.50
Firebox	6.86 x 3.5 ft.	8.03 x 3.4 ft.	10 x 3.3 ft.	8.03 x 3.4 ft.	9.02 x 3.4	9.7 x 3.4	9.7 x 3.4	8 x 3.25	6.5 x 3.61
Heating surf., tubes	1,242.24 sq. ft.	744.05	2,509 sq. ft.	915.6	1,398	1,695.57	1,498.0	1,780.7	1,243.3
" " total	1,378.19 "	870.16	2,582 "	1,034.8	1,549	1,893.76	1,675.3	1,907.7	1,349.3
Superheat, surface	.....	182.70	.....	231.45	356	448.40	419.6	.....	.....
Grate area	22.27 sq. ft.	27.11	33.14	27.11	30.55	32.25	32.25	25.8	24.0
Weight on drivers	36.30 tons	36 tons	36 tons	49.6 tons	52.6	51.5	81.5	44.3	65.6
Weight, total	53.35 "	66 "	73 "	49.0 "	70.2	82.3	52.5	61.7	65.6
" empty	48.80 "	55 "	67 "	45.8 "	64.2	75.5	76.0	56.4	51.2

* Engines Nos. 3 and 8 have Serve ribbed tubes.

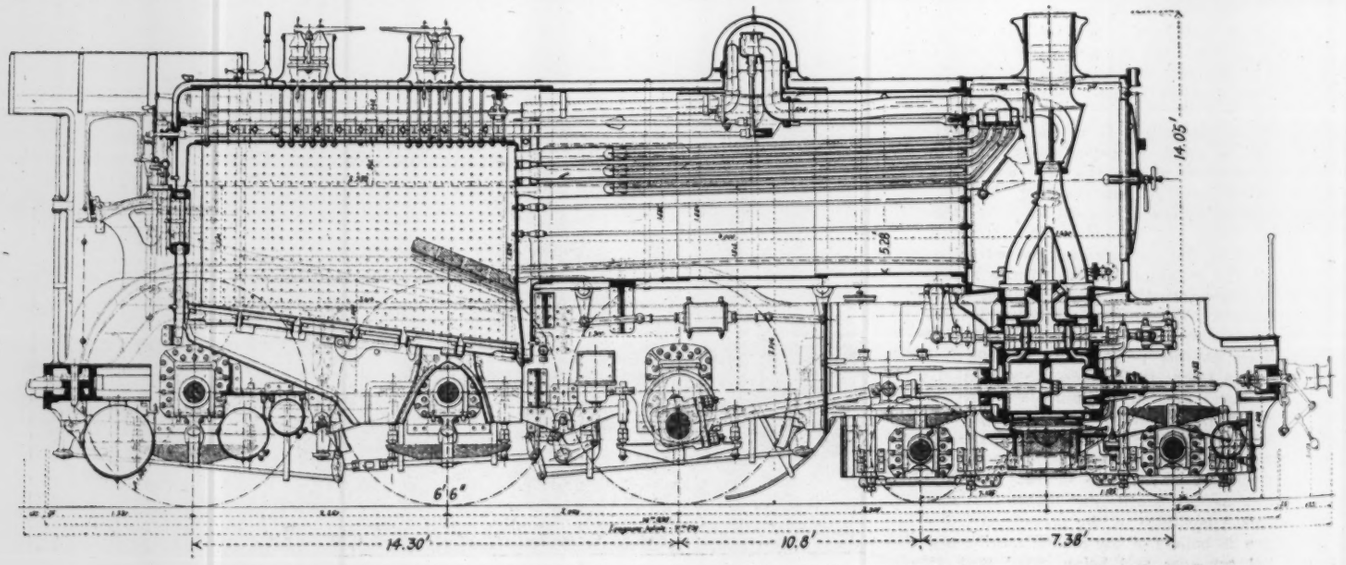


FIG. 2. SECTION OF FOUR-CYLINDER SIMPLE LOCOMOTIVE WITH SCHMIDT SUPERHEATER; BELGIAN STATE RAILWAYS.

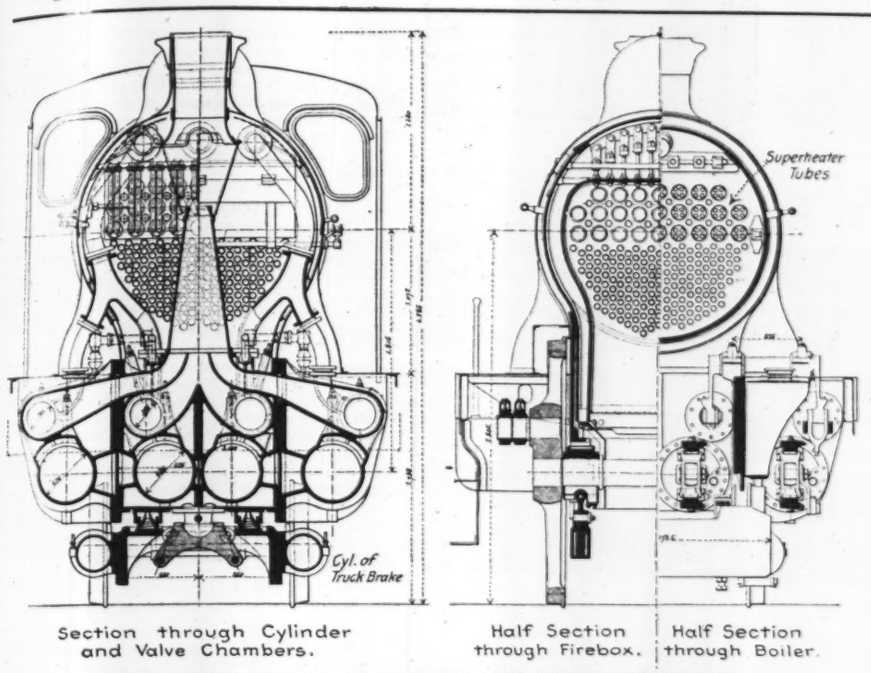

Superheater Tubes
Cyl. of Truck Brake
Section through Cylinder and Valve Chambers.
Half Section through Firebox.
Half Section through Boiler.

FIG. 3. CROSS-SECTION OF FOUR-CYLINDER SIMPLE LOCOMOTIVE.

anced compound of the well-known De Glehn system, with Walschaert valve gear outside the wheels. It is of the 4-4-2 class, but owing to the short runs and heavy loads the fast passenger engines are best handled by engines having six-coupled wheels, and the Belgian State railways have therefore built a number of 4-6-0 engines with 6-ft. wheels, which have the same boilers and mechanism as the 4-4-2 engines. The valve gears of the high and low-pressure cylinders can be operated simultaneously or independently by a hand lever which controls the three-way valves of two cylinders operating the reversing rods; this device is the invention of Mr. Flamme and Mr. Rongy, of the State Railways.

SIX-COUPLED ENGINES.—Engine No. 4 is a simple engine of the inside-cylinder 0-6-0 type so generally used in Europe for freight service; it is employed, however, as a "general utility" engine, handling fast freight trains and heavy passenger trains making frequent stops. The Belgian State Railways have over 260 of these in use, five of them being fitted with the Schmidt superheater. They can haul trains of 600 tons at 28 miles an hour, or passenger trains of 450 tons at 40 to 47 miles an hour. No. 5 is a ten-wheel (4-6-0) simple inside-cylinder engine of a class designed for light passenger trains on lines having heavy grades or heavy trains on more favorable lines; also for fast freight service. There are about 40 of the engines in use, with and without superheaters, and having driving-wheels of 5.3 ft. and 5.57 ft. diameter. No. 6 is an interesting engine of the 4-6-0 type; it is a four-cylinder compound with Cockerill superheater in the smoke-box and barrel, as shown in Fig. 1. There are 30 large fire tubes in the upper part of the boiler, each of which contains three small tubes, the small tubes extending from a steam chamber A in the boiler to another chamber B in the extension smoke-box. The main steam pipe extends from the throttle to the high pressure cylinders, the exhaust from which is passed through the superheater pipes before going to the low pressure cylinders. A damper closes the large tubes when the throttle is closed. The cylinders are arranged in line under the smoke-box, and all are connected to the front driving axle, as in the Von Borries system of compounding. The fan piston valves are operated by two outside valve gears of the Walschaert type.

No. 7 is still another ten-wheel engine of special interest, having four high-pressure cylinders, and intended for fast and heavy passenger trains. Only two have been built, and one of these has a Schmidt superheater. The four cylinders are placed in line under the smoke-box, and drive the first driving axle, the cranks being set at 90°. Each pair of piston valves is operated by an outside Walschaert valve gear, the tailrod of the outside valve being connected to that of the inside valve by a horizontal pivoted lever. A sectional elevation is given in Fig. 2, and the cross-sections in Fig. 3 show a rather astonishing complication of cylinders, piston valves and passages. The truck has a spherical center bearing. Engine No. 8 is a four-cylinder compound of the 4-6-0 type, with outside high-pressure cylinders connected to the second driving axle, and inside low-pressure cylinders connected to the first axle. The Belgian Northern Ry. has a number of these engines.

In Belgium there is an extensive system of light or local railways, constructed partly along the public roads, and operated by steam locomotives entirely enclosed in a cab, resembling a street car in appearance. One of the engines exhibited was a six-wheeled tank engine (0-6-0) for standard gage lines of this class, belonging to the National Light Railways Co., which has some 520 engines in its equipment. The engine was 23.7 ft. long over all, with its cab reaching to within 6 ins. of the rail; the tanks were at the sides of the boiler and at each end was a platform like that of a street car, with throttle, reversing and brake levers. The cylinders were 14 × 16 ins.; driving wheels 3 ft. diameter, on a wheelbase of 8.2 ft., and with a weight of 28.5 tons.

EIGHT-COUPLED ENGINES.—Engine No. 9 is a tank engine of the 0-8-0 type, representative of a numerous class employed for working heavy trains on steep grades. Engines of this class are employed on the 2½-mile grade of 3.1% at Liege, on the main line to Brussels.

FRENCH LOCOMOTIVES.

FOUR-COUPLED ENGINES.—Engine No. 10, in Table II., is a four-cylinder balanced-compound engine of the Atlantic (4-4-2) type, and represents a class of engines in very extensive use for passenger service on French railways. No. 11 is a high-speed passenger engine of the French State Railways, and was the only two-cylinder compound at the exhibition. It was originally a simple engine, converted to compound at the railway shops and fitted with the double valves invented by Mr. Nadal, Superintendent of Motive Power of the State Railways. Each cylinder has two piston valves, one for admission and the other for exhaust, as shown by the cross-section in Fig. 4; the two valve spindles are operated from a rocking shaft driven by a Walschaert valve gear, the two rocker arms of which are of different lengths. The valves are 10.4 ins. diameter for the high-pressure and 12 ins. for the low-pressure cylinder. A starting valve, operated by compressed air, admits live steam at reduced pressure to the low-pressure cylinder.

TABLE II.—TYPES OF FRENCH LOCOMOTIVES AT THE LIEGE EXHIBITION.

	10	11	12	13
Railway	Northern	Fr. State	Paris & Orl.	Southern
Type	4-4-2	4-4-0	4-6-0	2-8-0
Simple or comp	Comp., 4-cyl.	Comp., 2-cyl.	Comp., 4-cyl.	Comp., 4-cyl.
Cylinders, h. p., ins	13.6 x 25.6	17.6 x 26	14.4 x 25.6	15.6 x 26
" l. p. "	22.4 x 25.6	26.4 x 26	24 x 25.6	24 x 26
Driving wheels	6.90 ft.	6.70 ft.	6.07 ft.	4.60 ft.
Boiler, diameter	4.75 "	4.45 "	4.95 "	4.95 "
" rail to center	8.26 "	7.55 "	8.85 "	8.53 "
Tubes, No. and diameter	*126 — 2.8	*111 — 2.4	*139 — 2.8	*148 — 2.6
Tubes, length	14.10 ft.	12.0 ft.	14.43 ft.	14.10 ft.
Firebox	8.2 x 3.3	6.5 x 3.25	10.17 x 3.28	9.2 x 3.3
Heating surface, tubes	2,195.0 sq. ft.	1,581.7 sq. ft.	2,399	2,582.4
" " total	2,367.2 "	1,700.1 "	2,572	2,743.8
Grate area	29.7 "	21.5 "	33.35	30.2
Weight on drivers	33.75 tons	31.14 tons	53.4	65.7
Weight, total	47.70 "	54.29 "	73.8	72.8
" empty	41.55 "	49.00 "	67.6	65.5

*All engines have Serve tubes.

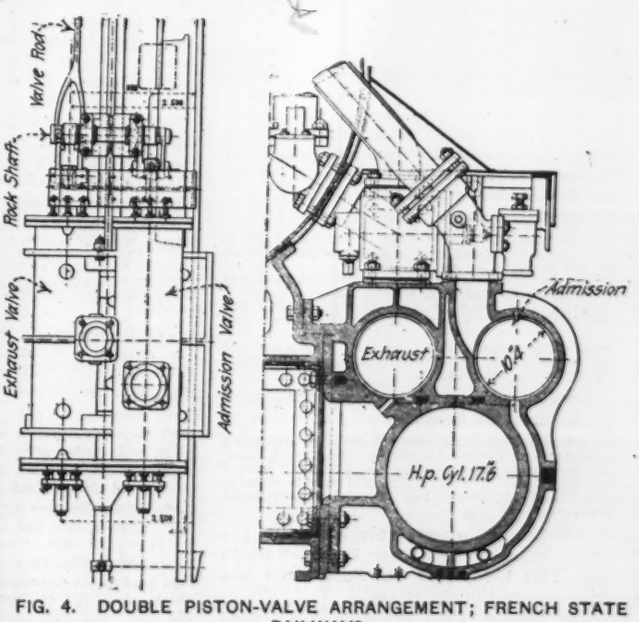


FIG. 4. DOUBLE PISTON-VALVE ARRANGEMENT; FRENCH STATE RAILWAYS.

SIX-COUPLED ENGINES.—Engine No. 12 is one of several ten-wheel (4-6-0) locomotives for hauling fast and heavy passenger trains on lines having severe grades. It is, like the others, a four cylinder balanced-compound, a type of compound which is now almost universally employed in France for service of this kind. In one of these, for the Western Railway of France, oscillating valves are used to open or close the passages for high-pressure exhaust when working simple or compound. As shown in Fig. 5, the valves A and B are on an oscillating shaft, C, and the shafts on both sides of the engine are operated simultaneously by a transverse compound-air cylinder.

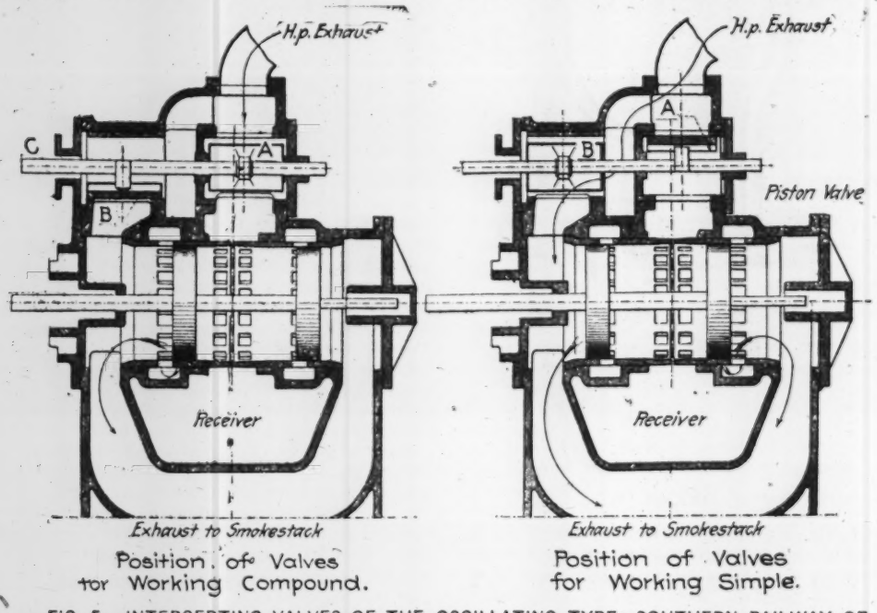


FIG. 5. INTERCEPTING VALVES OF THE OSCILLATING TYPE; SOUTHERN RAILWAY OF FRANCE.

EIGHT-COUPLED LOCOMOTIVE.—The last engine in the table, No. 13, is a four-cylinder compound of the consolidation (2-8-0) type, for hauling freight trains on a division of the Southern Ry. having grades of 2.7 to 3.3% and curves of 984 ft. radius.

DRAINAGE OF TIDAL AND SWAMP LANDS IN SOUTH CAROLINA.

Land drainage is being given no little attention in various parts of the United States, both by private interests and by the Irrigation and Drainage Investigations Division of the U. S. Department of Agriculture. In the last session of Congress a number of bills looking to drainage investigations, and at least one for extensive drainage construction work, were introduced. None of these bills were passed, but it is interesting to note briefly their contents. One which was to carry an appropriation of $25,000 directed the Secretary of Agriculture to investigate and report:

(1) The location and area of lands in the United States that are swamp and overflowed and susceptible of being drained and made fit for agriculture.
(2) The value and effect of drainage on such land and on the public health and upon agriculture.
(3) Existing legislation of the different States and localities on the subject of drainage and operations thereunder.
(4) Foreign drainage policies and their result, and the relation of the Federal Government to local authorities and legislation on said subject.

A second bill, proposing an appropriation of $20,000 directed the Secretary of Agriculture to cause a survey and investigation to be made of the swamp and tidal lands of Virginia, North Carolina, South Carolina and Georgia to determine the feasibility and cost of leveeing and draining said lands, and the benefits to agriculture and the public health which would result therefrom.

Still another bill provided for a loan of $1,000,000 to drain the Red River Valley of North Dakota. This bill passed the Senate and was favorably reported in the House.

There is little question but what much more will be heard in future sessions of Congress regarding the reclamation of swamp and other wet lands, especially in view of the large sums of public money now being expended for irrigation in the West.

Encouraged by the good results from work done by the drainage and sanitary commission on lands immediately surrounding Charleston, S. C., a drainage convention was recently held in that city and arrangements were made for promoting further work throughout South Carolina. Committees to represent different counties were appointed. During the convention a paper was presented, somewhat in the nature of a general report on the studies in South Carolina made by Messrs. Elwood Mead and C. G. Elliott, M.'s Am. Soc. C. E., of the U. S. Irrigation and Drainage Investigations. The paper was prepared by Mr. Mead. In discussing his subject he divided the lands in question into those of the coastal plain and of the river lands. A large part of the former are swampy and for the most part unfit for cultivation. The river lands are also unfit for use, unless protected by levees.

It appears, from facts given in the paper, that large areas of rice lands, some of which have been in cultivation for a century or more, have been and others must be abandoned, or at least other crops substituted for rice; this is largely due to changes in river conditions, including lack of fresh water required for flooding the rice fields. Mr. Mead states that rice-growing is "too hazardous to be continued where there is danger from salt water," and that "no other valuable field crop will grow on wet land." He names three conditions necessary to make the land suitable for cultivation:

(1) Strengthen the existing levees, rebuild those destroyed and make them high enough to withstand floods.
(2) Ditch the enclosed lands, so that soil water can be removed to a depth of 3 ft.
(3) Install pumping plants to remove all such drainage water as cannot be removed by gravity through sluices or trunks.

The method of levee improvement and drainage suggested for plantations along the Cooper River, together with estimated costs, is given in the paper as follows:

The work will be done with a light dredge with clamshell dipper, which will excavate a ditch 4 ft. deep and 20 ft. wide inside of and parallel with the river levee, depositing the earth on the river side and leaving a receiving and storage ditch for drainage. The levee will be made with wide base and 3 ft. higher than those now used. Such a levee and ditch can be made with a dredge for $1,200 per mile. The field drainage will be accomplished by parallel ditches 400 ft. apart, leading from the high land to the intercepting ditch near the river. These can be made at 8 cts. per lin. ft. A mile of river levee and ditch, with field drainage ditches, on a strip of land running about 300 acres per mile, with pumping plant at the lower end and sluice for gravity drainage will cost $4,400, or $14.66 per acre. Larger areas under one project will cost less and smaller ones more per acre. The annual expense of pumping and repairs would be about $1.50 per acre. The pump should be of the centrifugal type, which does not require an elaborate and expensive foundation, and by taking advantage of the system principle in the discharge the lift may always be reduced to a minimum.

The ditches executed in accordance with this plan will drain the soil to a depth of fully 3 ft., making the farm suitable for the growing of dry land crops, and the use of such machinery as will be required in the cultivation. It should be understood that the soil has been so long under water or completely saturated that after drainage it must be ploughed and exposed to the atmosphere for at least one season before it will be in proper tilth for the reception and growth of crops. With the surface turf should be mixed some of the clay subsoil to give it a firmness and capacity for retaining capillary water, which the surface soil does not possess. With such preparation there is every reason to believe that corn may be first grown successfully, and later cotton and forage crops. A failure thus far to grow crops of this kind upon these lands may be attributed to the fact that the attempt has been made where the drainage of the soil is too shallow and where no aeration of the subsoil has taken place. There is no question of the fertility or productiveness of the soil provided the mechanical and moisture conditions are such as are required by the deeper-rooted farm crops.

Similar work on the Santee River, Mr. Mead states, could be carried out at a cost of $11 to $12 per acre enclosed.

The coastal plain lands, it is estimated, have an area of 400,000 acres, only 50,000 acres of which are under cultivation. Gravity drainage and proper cultivation would make these lands not only productive but also very healthful and attractive. The disappearance of malaria after drainage in Illinois and Indiana is cited in support of the foregoing statement. Main drainage in those sections, consisting "of the artificial outlets required for farm and field drainage," cost $3 to $10 an acre. Mr. Mead thinks the coast lands of South Carolina could be drained in the same general way. He suggests that ditching machines should be used, so far as possible, for all the large ditches.

In conclusion, a general drainage law is outlined and the expediency and profits of the work are discussed. The paper concludes as follows:

These lands when drained will require but a fraction of the artificial fertilizing used on the higher lands and will be in such a condition that a rotation of crops suited to the climate may be followed and the fertility of the land be maintained. If looked into carefully it will be found that the value of commercial fertilizers used during two seasons upon the high lands will in many cases meet the expense of such a drainage system as will be required to make the low lands both healthful and productive.

The entire drainage problem may be summarized as follows:

The coastal section of the State must be drained before it will be sufficiently healthful to attract thrifty and intelligent farmers. This can be done in such a way as to make the country sanitary, with the exception of the river lands, for $5 per acre, and for high-class cultivation for $10 or $15 per acre. The tidal river rice lands, which are injured by salt water, should be converted into drained fields and planted in upland crops. This may be done at a cost of $15 an acre. If this were done on the two branches of the Cooper River that section would be free from malaria and the finely located residences could be occupied during the entire year.

A State drainage law should be enacted at the next Legislature, and in the meantime the plans and estimates for the drainage of a few representative tracts should be made and discussed for the information of the public.

The paper in full, together with the report of the drainage convention held in South Carolina, is published in the Charleston "News and Courier" for June 21, 1906.

LOCOMOTIVES WITH POPPET VALVES on the Lenz system are being tried on the Prussian State Railways (Germany), in order to obtain greater steam tightness with superheated steam, the ordinary slide valves being found to have a tendency to leak. The valves are either vertical or horizontal. In the former case each valve carries a roller resting upon a reciprocating rod having projections which engage with the rollers and so raise the valves, springs closing the valves when released. In another case the valves are horizontal and are operated positively in both directions by links from an oscillating or rocking shaft.

THE BAISELEYS, SPRINGFIELD, FOREST STREAM AND HEMPSTEAD FILTER PLANTS, BOROUGH OF BROOKLYN, NEW YORK.*

In connection with the surface water supply for the Borough of Brooklyn, New York City, four filter plants have been constructed; two of these, known as Baiseleys and Springfield, are mechanical filters of the gravity type, and have respectively a normal capacity of 5,000,000 and 3,000,000 gals. per day. These plants have wooden circular tanks, and are designed and operated in the usual manner, air being used to agitate the sand during washing. The water used for the plants is usually clear, although at the Springfield plant there is some sediment after rains. At the Baiseleys plant the cost of operation is increased, due to algae growths, especially in the late summer months.

The Forest Stream and Hempstead plants consist in each case of two slow sand beds, the Forest Stream plant having a daily capacity of about 6,000,000 gals., while the capacity of the Hempstead plant is about 3,000,000 gals. The area of the bottom of the beds at Forest Stream is 2.0 acres, and at Hempstead 0.9 of an acre. Each plant is divided into two beds of equal size. The beds have no covering and are constructed without an impervious bottom, side walls or dividing walls. Collecting pipes are laid below the ground water level, so that there is practically no loss of water by this form of construction. At the Forest Stream plant the entire bed is underlaid by gravel, and the 6-in. underdrains are spaced 12.25 ft. c. to c. The sand over the gravel was washed sand, having an effective size of about 0.29 mm. At the Hempstead bed the gravel is placed around the underdrains only, these being spaced 10.25 ft. c. to c. The sand for these beds was a clean, unwashed sand, having an effective size of about 0.27 mm. There has been no serious trouble experienced from freezing, but as the beds supply only a small fraction of the total water consumed, an interruption of the service for a few days would not be serious.

The operation of cleaning the bed at the Forest Stream filters is the usual one of scraping, the work being done by hand, and the material being removed either in wheelbarrows or in trucks. The water at this plant is clear, and the quantity of water filtered between scrapings has been approximately 60,000,000 gals. per acre. As the method of washing the beds at Hempstead, as hereinafter described, has proven successful, a contract was recently completed providing the necessary drain pipe for the Forest Stream beds, so that these beds can be washed instead of scraped.

At the Hempstead beds a new method of cleaning has been adopted, which is, practically, washing the surface of the beds. The beds are divided into channels, about 20 ft. wide, by means of boards set vertically, extending 8 to 9 ins. above the surface of the sand, the bottom of the board being about 6 ins. below the surface of the sand, thus preventing a flow under the same. These boards are laid to within about 15 ft. of the ends of the beds, and by placing planks across the channel ways the water can be sent through any one of the channel ways without causing any flow in the other channels. When the bed is ready to be cleaned it is drained so that only 4 or 5 ins. of water are left on the bed, and the gate on the waste pipe leading from the bed is opened; at the same time a gate on the pipe between the two beds is opened sufficiently to allow the raw water in the adjoining bed to flow on the bed that is to be cleaned. This gate is regulated so that the velocity of flow through the channel to be cleaned is just below that necessary to carry sand. Men with ordinary iron rakes then go over the surface of the bed in this channel way, and the dirt that has collected on the bed is stirred up and brought into suspension so that the flow of water carries it to the waste pipe. As the men work from the head of the bed towards the outlet, any of the dirt that may be deposited before it reaches the waste pipe is again brought into suspension and finally carried away.

After one channel way is cleaned, stop-planks are placed across the ends of this channel way and a second channel way cleaned. It is found that with this method one of the Hempstead beds can be cleaned in about four hours, by eight men, using about 225,000 gals. of water.

The cost of cleaning the beds by scraping has averaged about $1 per 1,000,000 gals., while the cost of cleaning the beds by washing has been about 40 cts. per 1,000,000 gals. The cost for scraping does not include any cost for new sand to replace that removed, and as the washing of the bed does not remove any of the sand, the cost of replacing the sand should be added to the cost given above for scraping. When the bed is cleaned by washing it has not been customary to attempt to wash all the dirt from the sand, as better bacterial results are obtained if the bed is not thoroughly cleaned. It is possible, however, by washing to entirely remove all dirt, and there is no evidence that the washing process cannot be carried on indefinitely. This system has been used for about a year and a half. The quantity of water filtered between cleanings has been reduced about one-quarter when the beds are washed, instead of being scraped.

Experiments will be made to determine whether the method of washing can be economically and efficiently applied to the proposed filters for the supply of the Boroughs of Manhattan and The Bronx. If the results are favorable it is expected to utilize this method on the new filters.

The bacterial results from the Hempstead bed had been excellent, the beds having usually less than 30 bacteria per cc., while the raw water has usually about 2,000, although frequently this number rises to over 100,000.

The operation of these filter beds is under an inspector of filters, who is a graduate of a technical school, and reports directly to the chief engineer. The inspector has an assistant and is provided with a laboratory equipped so as to make all necessary examination of the water, with the exception of complete chemical analyses, which are made at the Mount Prospect Laboratory. The waters from the filter plants are examined daily, and the thorough inspection increases considerably the cost of the filtered water.

These plants were designed and constructed and are being operated under the direction of Mr. I. M. deVarona, M. Am. Soc. C. E., Chief Engineer of the New York Department of Water Supply, Gas and Electricity. The accompanying tables, taken from Mr. deVarona's annual report for 1905, give cost and other data for the various filter plants for the year named.

*Prepared by request of this journal under the direction of Mr. I. M. de Varona, M. Am. Soc. C. E., Chief Engineer of the New York Department of Water Supply, Gas and Electricity.

TABLE SHOWING THE NET AMOUNT OF WATER FILTERED AT TWO MECHANICAL AND AT TWO SLOW SAND FILTER PLANTS, BOROUGH OF BROOKLYN, NEW YORK CITY, DURING THE YEAR 1905.

Month. 1905.	Net amount of filtered water, gals.	Cost of filtration. Inspection.	Operation.	Laboratory.	Repairs.	Interest and sinking fund.	Total.	Cost per million gals.
Mechanical Filter at Baiseleys.								
January	129,233,500	$22.15	$460.81	$28.60	$31.00	$268.22	$810.78	$6.27
February	140,456,400	22.15	342.12	28.60	28.00	268.22	689.09	4.91
March	127,588,800	22.15	393.27	28.60	31.00	268.22	743.24	5.83
April	123,625,700	22.15	324.13	28.60	30.00	268.22	673.10	5.44
May	132,230,260	42.34	339.50	39.54	56.43	268.22	746.03	5.64
June	131,700,920	45.41	354.60	37.24	49.85	268.22	755.32	5.73
July	111,691,300	38.18	378.54	29.65	16.50	268.22	731.09	6.54
August	105,782,900	67.19	440.51	62.69	45.00	268.22	883.61	8.35
September	60,736,580	60.10	371.86	42.39	19.50	268.22	762.07	12.54
October	106,436,700	46.73	434.33	45.02	48.00	268.22	842.30	7.91
November	140,119,300	50.05	342.77	37.20	49.50	268.22	747.74	5.34
December	125,907,100	46.20	531.64	35.55	103.00	268.22	984.61	7.66
Total	1,435,509,460	$484.80	$4,714.08	$443.68	$507.78	$3,218.64	$9,368.98	$6.53
Mechanical Filter at Springfield.								
January	57,774,840	$22.15	$276.48	$28.60	$31.00	$197.19	$555.42	$9.61
February	80,591,000	22.15	279.48	28.60	28.00	197.19	555.42	6.89
March	88,117,496	22.15	364.65	28.60	31.00	197.19	643.59	7.30
April	77,691,575	22.15	252.11	28.60	30.00	197.19	530.05	6.82
May	82,169,910	38.37	257.41	32.05	37.93	197.19	562.95	6.85
June	67,599,045	42.19	276.00	35.97	10.35	197.19	561.70	8.31
July	45,149,065	37.58	256.76	29.55	0.50	197.19	521.58	11.55
August	34,544,408	61.62	236.38	43.65	3.75	197.19	542.59	15.77
September	39,642,580	60.11	219.27	36.00	24.00	197.19	536.66	13.53
October	44,559,640	47.23	268.16	44.79	20.00	197.19	577.37	12.95
November	31,997,010	43.42	212.96	37.20	7.50	197.19	498.27	15.56
December	44,783,546	43.67	283.25	35.53	8.50	197.19	568.14	12.70
Total	694,611,415	$462.79	$3,182.91	$400.23	$232.53	$2,366.28	$6,653.74	$9.58
Slow Sand Filter at Hempstead.					Labor and materials.	Interest only.		
January	35,480,800	$22.15	.....	$28.60	$6.50	$27.50	$84.75	$2.39
February	20,602,200	22.15	.....	28.60	....	27.50	78.25	3.78
March	30,998,700	22.15	.....	28.60	14.75	27.50	93.00	3.00
April	23,639,500	22.15	.....	28.60	....	27.50	78.25	3.31
May	31,665,400	6.33	.....	27.00	....	27.50	60.83	1.92
June	49,746,200	4.38	.....	26.82	....	27.50	58.70	1.18
July	72,783,400	22.38	.....	28.21	....	27.50	78.09	1.07
August	32,329,800	11.00	.....	37.76	60.22	27.50	136.48	4.22
September	44,673,600	7.24	.....	39.15	56.00	27.50	129.89	2.91
October	30,717,000	24.90	.....	54.34	74.00	27.50	180.74	5.88
November	15,755,200	23.75	.....	44.51	12.00	27.50	107.76	6.84
December	28,301,600	26.18	.....	47.07	16.00	27.50	116.75	4.13
Total	416,783,400	$214.76	.....	$419.26	$239.47	$330.00	$1,203.49	$2.89
Slow Sand Filter at Forest Stream.					Labor,etc.	Interest.		
January	103,418,850	$22.15	.....	$28.60	....	$88.20	$138.95	$1.34
February	137,103,100	22.15	.....	28.60	....	88.20	138.95	1.01
March	94,409,200	22.15	.....	28.60	78.00	88.20	216.95	2.30
April	109,099,400	22.15	.....	28.60	159.00	88.20	297.95	2.73
May	68,276,200	30.25	.....	11.68	....	88.20	130.13	1.91
June	74,441,900	17.91	.....	14.76	....	88.20	120.87	1.62
July	105,406,700	24.81	.....	23.18	162.00	88.20	298.19	2.83
August	74,182,000	23.26	.....	27.16	29.00	88.20	167.62	2.26
September	76,644,000	32.63	.....	26.42	....	88.20	147.25	1.92
October	72,727,000	47.90	.....	44.79	165.00	88.20	345.89	4.76
November	60,635,000	42.20	.....	37.20	117.00	88.20	284.60	4.69
December	98,988,000	41.35	.....	35.53	....	88.20	165.08	1.67
Total	1,075,331,440	$348.91	.....	$335.12	$710.00	$1,058.40	$2,452.43	$2.28

A GASOLINE RAILWAY MOTOR CAR designed by Messrs. Hugh Mathews and W. F. Davis has recently been operated experimentally on the Missouri, Kansas & Texas Ry. The engine and mechanism was built at the works of Mr. Hugh Mathews, Kansas City, Mo., and the car was equipped at the railway company's shops at Parsons, Kan. The car is carried on two four-wheel trucks, one of which is the motor or driving truck, but with only one driving axle. An eight-cylinder horizontal engine of 170 HP. is used, and it is stated that no variable-speed gears are used, the speed being controlled entirely by the throttle. Large spur wheels on a shaft driven by the engine have connecting or coupling rods attached to these wheels and to the rear wheels of the truck. The spur wheel also drives a pinion on the cam shaft of the valve gear. Power is applied or released by means of cone clutches. A small compressor is supplied for the brake system and there are tanks for gasoline, water and compressed air. The car is 60 ft. long, and the total weight is 75,000 lbs. A six-wheel motor truck with an engine of 800 HP. is now being built.

IRRIGATION OF MEADOWS AND TRUCK FARMS IN THE NORTH ATLANTIC STATES.

A suggestive report on irrigation of meadows and truck farms in the North Atlantic States has just been published by the United States Department of Agriculture.* In his introduction the author very truly says that the "frantic efforts" made by farmers in times of drouth "to save their crops from destruction by hauling water and sprinkling from barrels and watering pots" are quite useless, since not enough water is applied to be of any service.

Water supply for irrigation in the East generally costs many times more than it does in the West, and its use is only made possible by "the high value of crops grown and the careful distribution of the small quantity of water used." This statement is meant by the author to apply more particularly to water taken from city waterworks system or else pumped independently from wells. Water bought as indicated usually costs $1 to $1.50 per 1,000 cu. ft., or $44 to $65 per acre-ft.; whereas in Santa Clara Valley, Cal., water is pumped to a height of 65 ft. at a cost of only $4.40 per acre-ft.

The report contains a list of 125 irrigated meadows in Lancaster, Berks, Lehigh and Northampton Counties, Pa. The areas of these meadows range from 1 to 65 acres; their combined area is more than 800 acres. Estimates indicate that the yield of the land is doubled by irrigation.

The report includes a table showing the location and acreage of 58 irrigated truck farms in Maryland, Pennsylvania, New Jersey, New York, Massachusetts and Rhode Island. These range in size from 1 to 100 acres.

The Pennsylvania State Insane Asylum, at Wernersville, irrigates 105 acres with sewage, of which 65 are in grass and 40 in potatoes. The crop yields given are 2½ tons of grass and 150 bbls. of potatoes per acre. Sewage disposal, it will be understood, is the primary object here. The sewage is received in a reservoir and conveyed therefrom through 3 and 2½-in. pipe and 2½-in. hose, the latter being attached [as needed] at 100-ft. intervals. The final distribution of the sewage is by means of furrows for the potatoes and slope flooding for the grass.

Where water is taken from streams, the report states, the diversion dams are generally cheap affairs. A dam owned by Julius Karabinus, in Northampton County, Pa., is of concrete, 84 ft. long, with an average height of 4 ft., a base width of 4 ft. and a top width of 1 ft. This dam is founded on rock, is provided with flashboards, and cost $340. The water made available by it

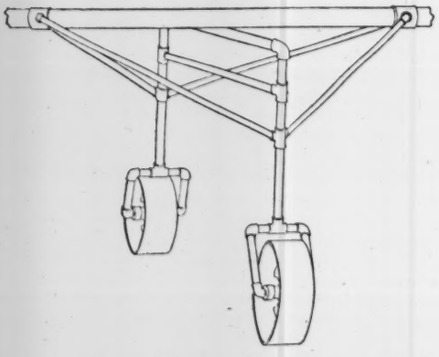


Fig. 1. Water Witch Carrier Used for Irrigation in Cumberland Co., N. J.

irrigates 7 acres of meadow land and 1 acre of truck garden.

One of the most interesting experiments described in the report is that of Mr. Henry A. Dreer, of Burlington County, N. J. Mr. Dreer irrigates five acres of flowers and strawberries. He pumps water from a brick-lined well 8 x 15 ft., which cost $200. The normal water level is 5 ft. below the ground surface, and the minimum level at the highest rate of pumping is 6 ft. below. The total height to which the water is pumped cannot be determined with exactness from the report, which merely states that the distribution pipes are "about 3 ft. above ground," without giving any information as to the variation of the ground level. It is probable, however, that there is not much variation in the surface level of the land. The duplex steam pump maintains a constant pressure of 50 lbs. by means of an automatic regulator which throttles the steam supply. The force main is 700 ft. long, and the laterals are 250 to 750 ft. in length and spaced 50 ft. c. to c. The laterals are supported on 2 x 4-in. scantling, 20 ft. c. to c. The plant and its operation is further described as follows:

> They [the laterals] are tapped for small brass plugs every 4 ft., the holes for the plugs being all in line. Each of these plugs has a pin hole in the center, which serves as an outlet for the water. The overhead pipe line is connected by a union to the supply pipe in such a manner that it can be easily turned at any angle. A valve admits water to each pipe. Each line is supposed to water 25 ft. on either side, and after one side is watered the pipe is revolved until the streams of water are at the proper angle for watering the other side. The water by the time it reaches the ground is in the form of a fine spray.
>
> The 250-ft. lengths of pipe are composed of 100 ft. of 1¼-in. pipe, 75 ft. of 1-in. and 75 ft. of ¾-in. pipe. The 750-ft. lengths are composed of 320 ft. of 1¼-in. pipe, 240 ft. of 1-in. pipe and 190 ft. of ¾-in. pipe. The small brass plugs, as well as the special drill provided with spirit level for boring holes in the same so as to have them in line, are both patented. The drill with spirit level sells for $10, and the brass plugs for 3 cts. each. The measured discharge from one brass plug was 0.3 gal. per min. In normal operation, one line of pipe will irrigate a space of 50 ft. in width in nine hours' run. This would correspond to a depth of irrigation of 1.3 ins. At its normal rate of operation, the pump is used to supply 9 lines 250 ft. in length, or 2,250 ft. of pipe, or 2½ acres. This would correspond to a rate of flow from the pump of 169 gals. per min. If desired, the pump could be run at double this capacity. All pipe in use throughout the plant is galvanized. The well water being clear, no trouble has yet been experienced with the small outlets in the brass plugs stopping up.
>
> The irrigation season lasts from the middle of April to the middle of October. The crops irrigated are flowers and strawberries. In dry weather they receive an irrigation every ten days, but they usually require not more than three irrigations per season. Irrigation is carried on, as a rule, between 7 p. m. and 4 a. m., in order to avoid scalding the crops and baking the ground. From 1.1 acres of irrigated land, where 91,000 plants were set out, 89,600 good potted plants were obtained, and from unirrigated land in former seasons not over 60,000 plants. As the value is $25 per thousand, this represents a gain of about $750 from irrigation.

Home-made canvas hose, for use under light pressure, is made by Mr. T. R. Hunt, of Hunterdon County, by cutting muslin cloth one yard in width into three strips, sewing the strips longitudinally and dipping them in a mixture of coal tar and oil. Short lengths of this hose are used to convey water down a slight grade to V-shaped wooden troughs. These are controlled by adjustable sliding gates and discharged into furrows.

Water witches are a common feature of many of the plants. These, as used by Mr. David Astle, of Cumberland County, N. J., in connection with a pumping system by which he irrigates 1.6 acres of land, are described as follows:

> The witches [Fig. 1] are set 10 ft. apart on a movable length of 2-in. pipe, which is mounted every 20 ft. on 2-wheeled carriages. Eleven water witches are mounted on 100 ft. of pipe supported by four carriages, and will irrigate, without moving, a space 110 ft. by 10 ft. Normally the water witches are run 20 minutes in the same place, but when necessary they are run for as long as an hour. Being mounted on wheels, the apparatus may be easily moved. In the driest seasons it has never been necessary to give the ground more than three thorough irrigations.

The water supply for Mr. Astle's irrigated area is pumped from wells to a 2,000-gal. elevated tank 44 ft. above the ground level. From this tank "the water flows back through 300 ft. of the supply pipe, and then through 800 ft. of 2-in. pipe to the land." Outlets 22 ft. c. to c. are provided for connecting the water witches by means of hose.

Sewage is used to irrigate six acres of land at the State Asylum for Feeble-minded Children, at Vineland, N. J., and in addition water for irrigating ten acres is pumped from wells. About 50,000 gals. per day of sewage is lifted 6 ft. by means of a 3-in. steam-driven centrifugal pump. From the tank a length of 500 ft. of sewer pipe discharges the sewage "over the land by flooding." At the time the report was made a part of the sewage was utilized on three acres of fruit and three acres of beans.

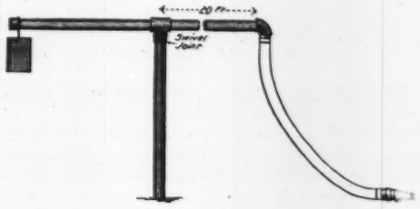


Fig. 2. Adjustable Irrigation Hydrant, with Hose and Nozzle, Used in Suffolk Co., Mass.

At some of the irrigating plants described in the report, the water is distributed through vertical pipes provided with sprinklers.

Fig. 2 shows an adjustable hydrant with hose and nozzle, used by the Hittinger Fruit Co., of Suffolk County, Mass. The pipe and hose are 2 ins. in diameter, and the latter is provided with a 1⅝-in. nozzle. These devices are spaced 150 ft. apart.

Fig. 3 shows a nozzle equipped with "an adjustable cone plug in the center for varying the size of the opening." It is used by Mr. W. H. Allen, of Middlesex County, Mass., who irrigates farms of 15, 35 and 45 acres, respectively.

Fig. 4 is described in the report as a "simple nozzle," and Fig. 5 as a "widely used type of water witch" consisting

> of a small revolving device with two concave horns which revolve, owing to the reaction of the water flowing between them. These sprinklers operate with a pressure of 15 to 30 lbs., and will cover a circle of 15 to 30 ft. in diameter. Their simplicity and cheapness have led to their wide adoption. The water passages through the sprinkler are fairly large and not easily clogged.

In summarizing his report, the author states that where the water is distributed by furrows or single sprinklers, not more than one man is required to look after the irrigation, and generally not more than half of his time is needed. With hose sprinkling, the entire time of one man per nozzle is required. Where multiple sprinklers are used, moving long lines of pipe requires an average of three men during about one-quarter of their working time, but, where all of the land is piped, instead of placing reliance upon movable pipes, "one man can look after an entire plant" [presumably meaning, if the plant is no larger than those listed in this report].

The estimated labor cost for one irrigation, with wages at $1.50 per day, ranges from 30 cts. to $1.20 per acre, with an average of 75 cts. where furrows are used. With hose the average cost of sprinkling is placed at $1.80 per acre; single witches, $1.12; multiple sprinklers, 45 cts. to $8.70 per acre, averaging $2.40. The depth of water applied at the above costs is 1.3 ins. by furrows, 0.6 in. by hose, 0.3 in. by single sprinklers, and 1.8 ins. by multiple witches. On this basis, the average labor cost of applying one acre-ft. of water is $7.10 by furrows, $34.80 by hose, $34.40 by single sprinklers, and $16.10 by multiple sprinklers. The advantages of a complete pipe distribution system, so far as labor costs are concerned, are shown by the low estimate of $3.50 per acre-ft. for this system. The various systems of applying water are discussed in the report as follows:

> The reason for the prevalence in the East of the sprinkling method of irrigation, which is practically unknown in arid sections, lies in two important differences in the conditions of irrigation practice. First, the quantity of water applied in one irrigation in the East must be small, owing to the risk of sudden and heavy rains which would swamp a crop if falling soon after a heavy

*Irrigation in the North Atlantic States.—By Aug. J. Bowie, Jr., Agent and Expert. Bulletin No. 167, Office of Experiment Stations. A. C. True, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ x 9 ins.; pp. 50; 7 illustrations in the text.

irrigation; and, second, the soils used for truck farming in the East are not, as a rule, so capable of storing and retaining water as the arid soils, so that a heavy irrigation once a month will not answer the needs of garden crops in the East. With the sprinkling system it is possible to apply uniformly as small a quantity of water as desired, while with furrows enough must be applied to run through the furrows and soak laterally to the roots of the plants.

In brief, the advantages of the sprinkling system are that there is no loss of space if the main pipes are laid underground, and no loss from leakage; it is applicable to uneven ground and hillsides, since water is delivered under pressure; no special preparation of the surface is required, and plants may be set as close as desired; a very small flow of water may be utilized, and a light irrigation may be very quickly applied in emergency. Its disadvantages are the great first cost for pipe and connections; the high pressure head which must be overcome when water is pumped; the excessive cost of city water where used, and the great expense of applying water and maintaining an elaborate system.

The advantages of the furrow system are its cheapness and simplicity, requiring only ordinary farm tools to lay out; the ease with which one man can handle a large stream of water; the fact that water is applied by gravity and need not be pumped higher than the land to be watered, dispensing with high storage tanks. Water may be applied at any time of day without danger of scalding the plants, since the foliage is not wet, and evaporation from the ground surface is reduced to a minimum. The disadvantages are: The loss of space where head laterals are used, and the expense of piping, where pipes are used instead of open-head ditches; the cost of leveling and smoothing land so that the furrows may carry the water without flooding; the expense of furrowing out before each irrigation and of cultivating afterwards, and the necessity of planting far enough apart for horse cultivation; the difficulty of applying water evenly in very sandy soil, and the loss of water by seepage in head ditches, especially where the flow used is small.

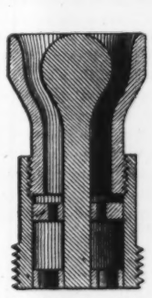


Fig. 3.

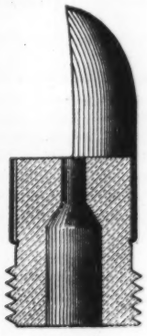


Fig. 4.

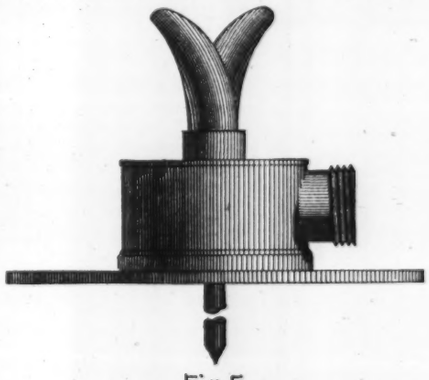


Fig. 5.

FIGS. 3 TO 5. TYPES OF NOZZLES USED FOR IRRIGATION IN THE NORTHEAST.

The foregoing cost figures have taken into account labor only. Mr. Bowie suggests that an allowance of 7% annually on the cost of a plant be made for interest and taxes; 13% for depreciation, repairs and renewals, and 20% for "total fixed charges on small pumping plants." It must be remembered that these figures apply, whether or not the plant is used. Further observations on the cost of irrigation are as follows:

Seven plants using city water irrigate 61 acres, the average cost of plant per acre being $44, while the cost per acre on individual plants varies from $12 on farm No. 18 to $188 on No. 44. The average fixed charges on the basis assumed are thus nearly $9 per acre annually.

Six gravity systems irrigate 15 acres, the first cost varying from practically nothing, in Nos. 11 and 12, to $100 per acre in No. 6, where a supply had to be developed.

Seventeen pumping plants, irrigating 388 acres, cost an average of $74 per acre, the least cost being $27 for No. 20, and the greatest being $455, for No. 27. The average fixed charges may be put at about $15 per acre.

The cost of city water is quite uniform, averaging in 13 cases $1.11 per 1,000 cu. ft., or about $48 per acre-ft. As the depth applied averages about 4 ins., the cost of city water per acre is $16.

The reasonable cost of pumping can hardly be determined from the small amount of data available, but comparison with skillful Western practice shows that the expense is unnecessarily high, due to several causes. In most pumping plants in the West the amount of piping used is small, and the pressure against which the pump operates is practically the lift alone. In the East, with the pipe distributing systems, the friction head and discharge head are often far in excess of the actual lift, necessitating much larger power plants and fuel consumption. Any system of sprinkling requires at least 20 ft. discharge head for hand sprinkling and twice as much for water witches, and larger heads are decidedly preferable. In any extended distributing pipe system there will necessarily be large friction losses in the pipe, since pipes large enough to cut down this loss would be too expensive.

The actual lifts of pumping plants in the East vary from 13 to 80 ft., while total pressure heads of 150 to 200 ft. are not uncommon, and in one plant the pressure head was 340 ft., of which only 32 ft. was actual lift. In other words, the power was eleven times that required to lift the water. On an average, the total head is probably three times the lift. Where elevated tanks are used, the work of pumping is often increased two or three times. In many places the power plant installed is fully six times as large as would be necessary were the water to be elevated only to the highest point of the ground to be irrigated.

Of twelve cases, the average of the cost per acre-ft. for fuel and labor is $13.15 where steam power is used. Adding to this the fixed charges given above, the total cost of providing and distributing water, but not applying it, is $28 per acre-ft. A cost of $28 per acre-ft. for water delivered at the point where it is ready to be applied to the fields is very high in comparison with Western costs.

In six plants using gasoline engines the average cost for gasoline per acre-ft. pumped is $2.91, as against $6.18 for fuel alone for coal plants. This difference is due to the greater heads under which the coal plants operate—perhaps four times the average head for the gasoline plants—and to the use of direct-acting steam pumps, which are very wasteful of steam. Gasoline plants should be more widely adopted in the East, except where steam plants obtain their steam from boilers used for other purposes, such as heating in the winter time, and thus effect a saving in first cost over the gasoline plant. The average steam plant under the conditions observed cost over four times as much for fuel and attendance as the average gasoline plant.

As to the net returns from irrigation, the report states that it is particularly difficult to arrive at these in a humid country,

owing to great variations in the distribution of rainfall, the nature of the soil and the subsoil, and to the effects of severe rains. For example, in a dry year unirrigated crops may be a total failure, and irrigated crops be as large as ever, while in a wet year irrigation may prove a positive detriment.

An average for a long period of years would be required as a basis for reliable estimates. Mr. Bowie concludes that there may fairly be assumed an average profit of $200 or more per acre from irrigation. Finally, it may be noted that, in his opinion, truck crops require about 1 in. in depth of water per week, in the form of either rain or irrigation. In light, sandy soils this "should be applied in quantities not exceeding 1 in. at a time."

THE RAILWAYS OF CAPE COLONY aggregated 2,750 miles at the end of 1904. New 80 and 85-lb. rails are replacing old 60-lb. rails on the main lines, but the use of heavier rolling stock and higher speeds tends to increase the cost of maintenance of way. There were 172 cases of broken rails, all but nine of which were in 41¼-lb. and 60-lb. rails; the breakages of splice bars continued to be numerous, aggregating 5,776 bars of light section and 17,183 bars of heavy section. The four government tie-plantations aggregate 1,265 acres, and are planted with different species of eucalyptus; they have, however, only about two years' growth. The results obtained by boring for water for the locomotives have afforded considerable relief at different points on the system. Mr. T. S. McEwen is General Manager; Mr. Alan Grant-Dalton, Engineer in Chief, and Mr. H. M. Beatty, Chief Locomotive Superintendent.

REPORT OF THE BRITISH ROYAL COMMISSION ON MOTOR CARS.

When any especially troublesome question of wide public concern arises in England, it seems to be the fashion to refer it to a royal commission for investigation and report. The latest result of such action which has come to our attention is the report of the Royal Commission on Motor Cars, made public on July 25. Early news regarding this report indicated that the commission had advised, among other things, the complete abolition of all specific limitations on speed; but, as will be seen from the following summary of the report (based on a brief article in the London "Surveyor" of July 27), the recommendation was not quite so sweeping as former reports seemed to imply. The main recommendations are as follows:

(1) The abolition of the limit of 20 miles an hour for light cars, speed to be controlled by the section of the act making it an offence to drive recklessly, negligently, or in a way dangerous to the public; a limit of 12 miles for inhabited places, dangerous corners, and hills, etc., where adopted by the authorities, to be indicated by signals, or in large towns by due advertisement.

(2) The limit for cars weighing from 2 to 3 [long] tons with non-resilient tires to be five miles an hour. Any general motor-car act also to deal with traction engines.

(3) A central department to allocate the revenue from taxation of cars to the authorities for the improvement of roads. Amendment of the law as to extraordinary road damage by heavy traffic.

(4) Annual registration with yearly fees; registration card to be always carried.

(5) Emission of smoke or visible vapor so as to cause annoyance or danger, and excessive noise or vibration not momentary to be an offence.

(6) Slightly larger identification plates to be supplied by local authority only; two lamps on the right and left front (not for motor-cycles); and regulations as to position and illumination of identification marks.

On the subject of dust, which seems to have been one of the chief promoting causes for the appointment of the commission, the commissioners suggested that the least dust is produced by a car standing well above the ground, but wisely refrain from laying down any rules for car construction. It states that the dust nuisance increases very greatly with increases in speed between 12 to 20 miles per hour, but less directly with higher speeds.

Roads better suited to carry heavy traffic, especially in the case of main roads, are advised. Dust preventives the commission does not consider as yet being beyond the experimental stage.

The number of motor cars in use [presumably in England and Wales] increased from 51,000 on Jan. 1, 1905, to 88,600 on May 1, 1906. Prosecutions for "motor car offenses" for the year ending June 30, 1905, numbered 6,165, of which 739 were withdrawn or dismissed. The total amount of fines imposed was about 60,000. Motor taxes for the year 1905-06 amounted to about $487,000.

A HOSPITAL CAR for carrying sick and delicate children to the public health establishments at Berck and Hendaye, France, has been built to the order of the Government Director of Public Assistance, and was designed by M. Chevalier. It has accommodations for 42 children of 3 to 15 years of age, three nurses, two doctors and a superintendent. The length over the steel underframe is 48.67 ft., and the maximum width is 9.67 ft.; it is mounted on two axles 27 ft. c. to c., with long plate springs over the boxes, and weighs empty about 39,600 lbs. The interior is arranged like an American sleeping car, with seven sections on each side; the seats are low enough to be comfortable for children, and the upper berths are low enough to enable the nurses to attend to the children. There is only one window to each section, and that is in the space between the seats; no air is admitted through these, for fear of drafts, but special ventilating arrangements are provided. The car has a monitor roof with deck lights. At one end is a private section for the doctors, opposite to this being the compartment for the heater. At the other end are a toilet room and a private section for the nurses. In each side (and near opposite ends) is an entrance. A partition near the middle of the car divides it into two compartments for boys and girls, respectively. The car can be run on any railway, as required.

THE STABILITY OF SEA WALLS.

By D. C. Serber.*

A sea wall is a retaining wall designed to withstand the pressure of the backing behind it, which is supposed to carry an assumed load. The tide rises behind the wall, as well as in the open sea, even slightly higher, due to the capillary action of the filling. Hence, during high tide the backing material is saturated, and the pressure against the back of the wall is to be assumed normal to it, or, in other words, friction of the backing against the wall, which adds to the stability of a retaining wall, must be neglected. The only portion which always remains dry is that above high tide, which is small in comparison with the entire depth of the wall. The top of the backing is always horizontal, while the back of the wall will be assumed either vertical or stepped off vertically. The main difference between an ordinary retaining wall and a sea wall is that, while the backing material behind the former is homogeneous (or can be assumed to be so), the material behind the latter is heterogeneous. Riprap, earth and cinders are used in different layers, and even the same material changes in weight, depending on whether it is placed below high tide or above it.

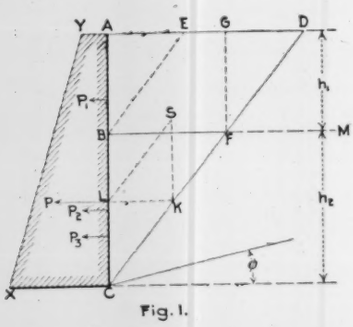


Fig. 1.

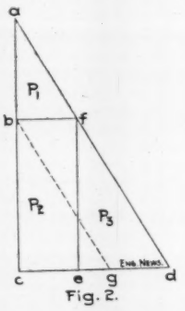


Fig. 2.

CASE 1. Backing Homogeneous.—Let A C X Y, Fig. 1, be the cross section of a sea wall one foot long, with the back A C vertical and the top A D of the back-filling horizontal.

Rankine's formulas for earth pressure are:

$$p = wh\,\frac{1+\sin\phi}{1-\sin\phi} \qquad (1)$$

$$P = \frac{wh^2}{2}\,\frac{1+\sin\phi}{1-\sin\phi} \qquad (2)$$

where p = intensity of normal pressure at any depth h,
w = Weight per unit of volume of backing.
ϕ = Angle of natural slope of the backing with the horizontal.
P = Total normal pressure on a portion of the wall of the depth h.

By trigonometric formulas equations (1) and (2) may be changed to:

$$p = wh\tan^2 \tfrac{1}{2}(90^\circ - \phi) \qquad (3)$$

$$P = \tfrac{1}{2}wh^2\tan^2 \tfrac{1}{2}(90^\circ - \phi) \qquad (4)$$

Formulas (3) and (4) are general. They are applicable to liquid as well as to earth pressure. For, when $\phi = 90°$, as is the case in solid rock, p = P = 0, that is, there is no thrust. When $\phi = 0$, as is the case in liquids, p = wh and P = ½ wh², as should have been expected. These values of p and P are limits, corresponding to the limiting values of ϕ, and for any intermediate value of the latter the former will take intermediate values according to formulas (3) and (4). In both liquid and earth pressures the intensity varies uniformly from zero at the top of the wall to a maximum at the bottom, provided, of course, that ϕ in earth embankments is constant, which has to be assumed until a contrary condition and its law of variation have been established and proved beyond doubt.

It will be shown, later on, that the analogy between liquid and earth pressures is borne out also in the analysis of the effect of a surcharge on a wall, when its top is horizontal. It is to be remembered that the discussion involves only horizontal pressures.

If C D in Fig. 1 be a line drawn to bisect the complement of the angle of repose ϕ, then

$$A\,C\,D = \tfrac{1}{2}(90^\circ - \phi)$$

$$A\,D = h\tan\tfrac{1}{2}(90^\circ - \phi)$$

$$\text{Area } A\,C\,D = \frac{h^2}{2}\tan\tfrac{1}{2}(90^\circ - \phi)$$

$$\text{Hence, Weight of prism } A\,C\,D = \frac{wh^2}{2}\tan\tfrac{1}{2}(90^\circ - \phi) = W.$$

If this weight is multiplied by $\tan\frac{1}{2}(90^\circ - \phi)$ a value is derived which is identical with P of Eq. (4). The prism A C D is called the prism of maximum pressure, and the graphical method of finding the total thrust is obvious from Fig. 1, where S K = W and S L is parallel to C D, making angle L S K = ½ (90° − ϕ), thus giving K L = P. If S is the center of gravity of A C D, then will L, where K L intersects A C, be the point of application of the thrust, and L C = ⅓ A C.

Considering ϕ constant and p and h variable, equation (3) is the equation of a straight line. In other words, the pressure varies uniformly from 0 at the top to a maximum at the foot of the wall. If, then, in Fig. 2, the vertical ac represents the total height of the wall, and cd the horizontal line represents the intensity of pressure at the foot of the wall, then the area acd will represent the total pressure P.

Let BM in Fig. 1 be any horizontal plane through the back-filling. The total pressure P on the wall is equal to the sum of the partial pressures $P_1 + P_2 + P_3$ on AB and BC respectively. In Fig. 2, abf represents the total pressure on AB. The pressure on BC, or the remaining portion bcdf, is due, first, to the immediate backing below the plane BM represented by the area bgc = fed, and, second, to the mass above BM, acting as a uniform surcharge over the wall BC; consequently, the pressure on BC due to the mass above BM is expressed by the area bcef. This being a rectangle, it is evident that the intensity of pressure due to the surcharge must be uniform. The superposed weight, penetrating, as it were, into the mass below BM, produces a conjugate pressure on BC, the value of which depends, as will be seen later, on the angle of repose of that mass. The value of this pressure of course also depends on the weight of the prism EBFD = AEFG. For, if the planes BM and XC are assumed to retain their relative positions, while the plane AD is raised or lowered, thus increasing or decreasing the amount of mass in ABFG, the pressure fed will remain unchanged, while bfce will vary directly with the change in the height AB; while, if the plane BF is imagined to be a cantilever or a relieving platform of sufficient strength to sustain the weight above it, the area bfce will vanish, and BC will be relieved of that pressure.

The analytical expressions of the partial pressures shown in Fig. 2 can be written with the aid of Eq. (4) as follows:

$$acd = P = \frac{w(h_1+h_2)^2}{2}\tan^2\tfrac{1}{2}(90^\circ - \phi) \qquad (5)$$

$$abf = P_1 = \frac{wh_1^2}{2}\tan^2\tfrac{1}{2}(90^\circ - \phi) \qquad (6)$$

$$fed = P_3 = \frac{wh_2^2}{2}\tan^2\tfrac{1}{2}(90^\circ - \phi) \qquad (7)$$

$$bfce = P_2 = P - (P_1 + P_3) = wh_1 h_2\tan^2\tfrac{1}{2}(90^\circ - \phi) \qquad (8)$$

Eq. (8) can also be written

$$bfce = [wh_2\tan\tfrac{1}{2}(90^\circ - \phi).\ h_1]\tan\tfrac{1}{2}(90^\circ - \phi) \qquad (9)$$

Here the expression in brackets is the weight of prism ABFG, while $\tan\frac{1}{2}(90^\circ - \phi)$ is the factor transforming that weight into conjugate pressure, precisely as was shown before in finding the value K L, Fig. 1. Eq. (8) can also be written

$$bfce = bf.\ bc = bf.\ h_2 \qquad (10)$$

and from Eq. (3):

$$bf = wh_1\tan^2\tfrac{1}{2}(90^\circ - \phi) \qquad (11)$$

Equation (10) shows that the intensity of pressure is uniform, while Eq. (11) gives the value of that intensity.

It will be shown further, that with heterogeneous backing these principles hold true, provided ϕ in Eq. (8), (9) and (11) is the angle of natural slope of the *lower* mass.

CASE 2. Heterogeneous Backing of Equal Density but Unequal Angle of Repose. If in Fig. 1 the mass above BM is assumed the same as before, while that below BM is solid rock, as shown in Fig. 3, then it is evident that there will be no thrust on BC. This is seen from Eq. (7) and (8), by making $\phi = 90°$:

$$fed = \frac{wh^2}{2}\tan^2 0 = 0.$$

$$bfce = wh_1.\ h_2.\ \tan^2 0 = 0.$$

Fig. 4 gives the same result graphically. If, with the same conditions for the mass above BM, the mass below that line is liquid, as shown in Fig. 5, then making $\phi = 0$ in Eq. (7) and (8), there results:

$$fed = \frac{wh^2}{2}.$$

$$bfce = wh_1\,h_2.$$

expressions which can be obtained, independently, from Pascal's law of liquid pressure, where fed is the total pressure exerted on the side of a vessel by the contained liquid, and bfce is the total lateral pressure due to a uniform weight applied at the surface of the liquid. The pressures for this case are shown in Fig. 6. These two cases are the limits of variation of the angle of natural slope, and by the principle of continuity it is perfectly logical to assume that any deduction or conclusion arrived at with these values of ϕ will hold equally true for any of its intermediate values, as shown in Figs. 7 and 8. In all these cases, the angle of repose of the mass above the plane BM has no influence whatever on the portion BC of the wall. The upper mass is merely a surcharge for the wall BC producing on it a pressure of uniform intensity bf_1, no matter whether that upper mass is solid rock with $\phi = 90°$ or water with $\phi = 0°$. The position of f_1, and hence the value of bf_1, will depend only on the degree of solidification of the mass below BM, that is on its angle of repose. Therefore Eq. (8), (9) and (11) hold true for these cases, when the value of ϕ is that of the lower mass.

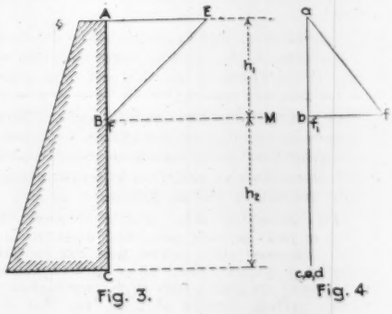


Fig. 3.

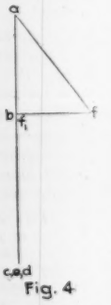


Fig. 4.

The total pressure, then, for the case shown in Figs. 7 and 8 will be:

$$P = \frac{wh_1^2}{2}\tan^2\tfrac{1}{2}(90^\circ - \phi_1) + wh_1h_2\tan^2\tfrac{1}{2}(90^\circ - \phi_2) + \frac{wh_2^2}{2}\tan^2\tfrac{1}{2}(90^\circ - \phi_2)$$

$$= \frac{w}{2}\left[h_1^2\tan^2\tfrac{1}{2}(90^\circ - \phi_1) + \left\{2h_1 + h_2\right\}\tan^2\tfrac{1}{2}(90^\circ - \phi_2)\right] \qquad (12)$$

Substituting the shorter expressions

$$\theta_1 = \tfrac{1}{2}(90^\circ - \phi_1)$$

$$\theta_2 = \tfrac{1}{2}(90^\circ - \phi_2)$$

$$\text{and } m = \frac{h_1}{h_2}, \text{ that is } h_1 = mh_2,$$

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...ation (12) becomes

$$P = \frac{wh_2^2}{2}\left[m^2 \tan^2\theta_1 + (2m+1)\tan^2\theta_2\right] \quad (13)$$

...ry important conclusions have been ar...d at, so far, with regard to the nature of the ...ssure bfice: First, it has been proved that ... pressure is of uniform intensity; Second, it ... been shown that it depends on two factors, ... being the direct weight of the mass resting ... BM, and the other the angle of natural slope, ...ich converts this direct pressure into a horizontal conjugate stress of thrust. The first factor is the weight of the prism *above* BM, while the second is the angle of natural slope of the medium *below* BM. The final conclusion, then, is that the total pressure on the lower section of wall, BC, is entirely independent of the angle of natural slope of the material above BM. Although the total weight above BM is that of prism ABDF (Fig. 1), the vertical pressure is produced only by prism ABFG, no matter what the direction of FD is, as the parallelogram EBDF will always remain equal to ABFG. The reason for this seemingly paradoxical discrepancy between the weight and the pressure on BF is that a portion of the weight, namely that of EDF, will be supported by the horizontal projection of FD. This is analagous to a case of liquid contained in a vessel ABFD, where the pressure on BF is equal to the weight of ABFG.

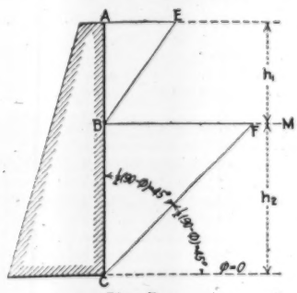

Fig. 5.

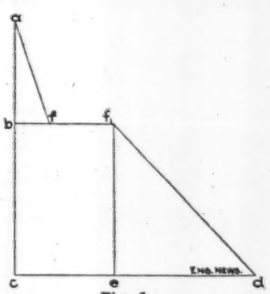

Fig. 6.

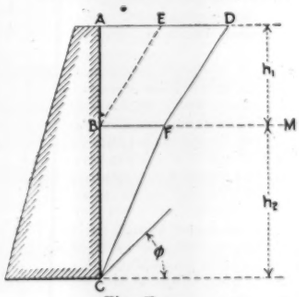

Fig. 7.

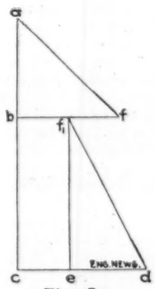

Fig. 8.

CASE 3. Backing Heterogeneous in All Respects.—Let the material above BF be different from the one below that line in density as well as in natural slope, the latter being smaller in the lower mass, as shown in Fig. 9.

As before, the total pressure on AC is, (Fig. 10),

$$P = abf + bcef_1 + f_1ed \quad (14)$$

The term $bcef_1$, as has been demonstrated before, is the conjugate horizontal pressure on BC due to the weight of prism ABFG of the material above BF and to natural slope of the mass below that line. If mn represents the weight of ABFG, while ms is drawn parallel to FC, then will ns be the graphical representation of the total normal pressure exerted by the material above BF on BC, in other words $ns = bcef_1$. This pressure, being of uniform intensity, as was shown, if divided by $BC = h_2$, will give the intensity of pressure bf_1, and thus the position of point f_1, Fig. 10, will be determined from the equation $bf_1 = \frac{ns}{h_2}$.

That f_1 may or may not coincide with f becomes apparent if the mass below BF is imagined to solidify, that is, to change its natural slope, while the density of both masses and the angle of natural slope of the material above BF remain unchanged. The greater the cohesion is within the mass below BF, the greater is its angle of repose, and the smaller is the pressure ns and, consequently, bf_1, while bf remains the same. Finally, when this mass becomes perfectly rigid, f_1 coincides with b, and the pressure $bcef_1$ vanishes altogether. If, on the other hand, the angle of natural slope of the lower mass decreases, f_1 will move in the opposite direction, bf_1 will increase and reach its highest value when this mass becomes liquid, as shown in Figs. 5 and 6. At a certain value of the angle of slope of the lower mass, f_1 will coincide with f; at all other values there will be two intensities of pressure in the neighborhood of point B, one immediately above the division plane BF and one immediately below it. As already found, the thrust on BC due to the surcharge ABFG is, if w_1 and ϕ_1 are the unit weight and angle of repose of the upper mass, while w_2 and ϕ_2 the corresponding values for the lower mass

$$ns = w_1h_1h_2 \tan^2 \tfrac{1}{2}(90° - \phi_2)$$

and the corresponding unit pressure along BC is

$$bf_1 = w_1h_1 \tan^2 \tfrac{1}{2}(90° - \phi_2)$$

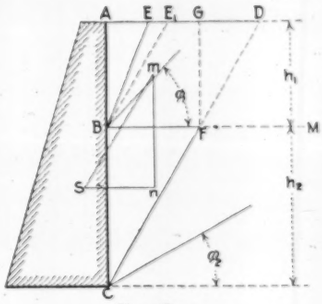

Fig. 9.

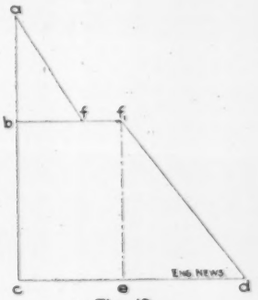

Fig. 10.

Since the pressure bf is

$$bf = w_1h_1 \tan^2 \tfrac{1}{2}(90° - \phi_1),$$

it follows that

$$bf > bf_1 \text{ when } \phi_1 < \phi_2$$
$$bf = bf_1 \text{ " } \phi_1 = \phi_2$$
$$bf < bf_1 \text{ " } \phi_1 > \phi_2$$

The analysis remains the same, no matter what the relative values of ϕ_1, ϕ_2, w_1 and w_2 may be. Therefore, the expression for the total pressure, which will now be given, is general. Substituting in Eq. (14),

$$P = \frac{w_1h_1^2}{2}\tan^2 \tfrac{1}{2}(90° - \phi_1) + w_1h_1h_2 \tan^2 \tfrac{1}{2}(90° - \phi_2) + \frac{w_2h_2^2}{2}\tan^2 \tfrac{1}{2}(90° - \phi_2) \quad (15)$$

$$\text{or, } P = \frac{w_2h_2^2}{2}\left[m^2n \tan^2\theta_1 + (2mn+1)\tan^2\theta_2\right] \quad (16)$$

where, $m = \frac{h_1}{h_2}$, $n = \frac{w_1}{w_2}$, $\theta_1 = \tfrac{1}{2}(90° - \phi_1)$, $\theta_2 = \tfrac{1}{2}(90° - \phi_2)$.

By expressing w_1 in terms of w_2 the entire backing is reduced to the same density, and, therefore, the graphical method of finding the pressure is very much simplified, as in this way the portion BC of the wall is acted upon by a homogeneous mass, the angle of repose being ϕ_2 throughout. After $P_1 = abf = \frac{w_1h_1^2}{2}\tan^2\theta$ has been found as shown in Fig. 1, and its point of application determined as shown in Figs. 11 and 12, the density w_1 of the mass above BM is reduced to w_2 by making $h_3 = nh_1 = mnh_2$, so that the reduced surface is A_1N_1. Then BC is acted upon by the homogeneous mass $A_1CFG_1 = E_1BCD_1$, which produces a pressure $P_2 = bcef_1 + edf_1$. The point of application of P_2 is found by taking moments around an axis through C, remembering that the resultant of $bcef_1$ is equally distant from B and C, while that of edf_1 is one-third of BC from C. Then

$$RC = \frac{\tfrac{1}{2}\,m\,n\,w_2h_2^2\tan^2\theta_2 + \tfrac{1}{3}w_2h_2^2\tan^2\theta_2}{m\,n\,w_2h_2^2\tan^2\theta_2 + \tfrac{1}{2}w_2h_2^2\tan^2\theta_2} = \frac{3\,mn+1}{2\,mn+1}\cdot\frac{h_2}{3} \quad (17)$$

This value of RC indicates that the point R of application of P_2 is at the intersection of BC with a line drawn parallel to CD through the center of gravity BCD_1E_1. The two pressures are then combined by the principle of the lever and the position of P thus found. In practice such refinement is unnecessary as P will always be found at or very near to the point S making $SC = \frac{1}{3}AC$.

It is worth noting that in Fig. 12 the line f_1d must pass through the point a_1, corresponding to the reduced surface A_1N_1. This fact is a convenient check on the work.

CASE 4. Surcharge.—Merchandise, cranes and other loads of considerable weight are apt to be stored temporarily or permanently on the sea wall and the backing immediately behind it.

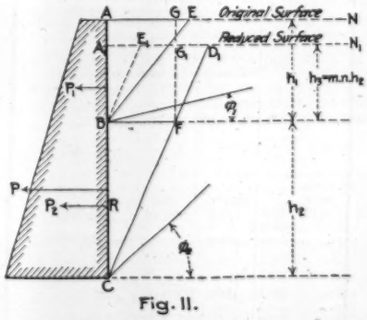

Fig. 11.

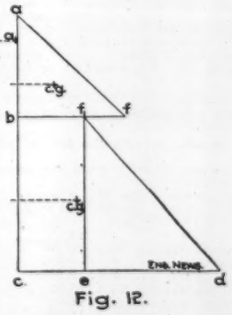

Fig. 12.

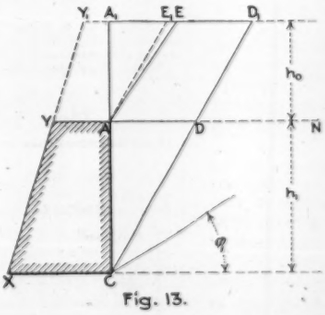

Fig. 13.

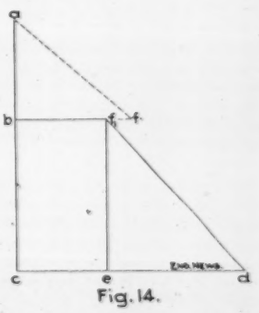

Fig. 14.

The Department of Docks and Ferries of New York City assumes a uniform vertical load of 1,000 lbs. per sq. ft. The wall, therefore, must be designed to resist the lateral pressure induced by this weight. In Fig. 13 let ACYX be a section of the wall and AN the top of the backing, carrying a uniform load of W pounds per sq. ft. Let the intensity of this load be assumed w_0 giving it a height $A_1A = h_0 = \frac{W}{w_0}$. Both h_0 and w_0 are arbitrary. The portion of the load A A_1 Y Y_1 resting on the wall, of course, adds to its stability, and therefore the load will be assumed to extend only to A A_1. Also let the angle of natural slope of the load be assumed ϕ_0, while the unit weight and angle of repose of the backing (which is taken as homogeneous) are w_1 and ϕ_1. If the wall is imagined to extend to A_1Y_1, then the pressure on A_1C can be found precisely as in Case 3, Figs. 13 and 14 being merely a reproduction of Figs. 11 and 12. The pressure on AC then is $bcdf_1$, which is the actual total pressure on the given wall ACYX. This can now be readily found from Eq. (15) by making

$$\tfrac{1}{2}\, w_0 h_0^2 \tan^2 \tfrac{1}{2}(90^\circ - \phi_0) = 0$$

whence $$P = \left(w_0 h_0 + \frac{w_1 h_1}{2}\right) h_1 \tan^2 \tfrac{1}{2}(90^\circ - \phi_1)$$

while the intensity of pressure at A is

$$p = bf_1 = w_0 h_0 \tan^2 \tfrac{1}{2}(90^\circ - \phi_1)$$

Substituting for w_0h_0 in the last two expressions, its value W,

$$P = \left(W + \frac{w_1 h_1}{2}\right) h_1 \tan^2 \tfrac{1}{2}(90^\circ - \phi_1) \qquad (18)$$

and $$p = W \tan^2 \tfrac{1}{2}(90^\circ - \phi_1) \qquad (19)$$

These expressions for P and p show, that the lateral pressures caused by the surcharge are independent of the angle of repose and of the height of the latter. Hence, h_0 can be selected so as to make $w_0 = w_1$, in other words the surcharge may be reduced to the density of the backing and the pressure found graphically as in Fig. 11, omitting P_1.

The relative effect of the surcharge on the wall can be easily seen by comparing W and $\frac{w_1 h_1}{2}$ in Eq. (18). Thus if W = 1,000, while $w_1 = 100$ and $h_1 = 20$ ft., the surcharge produces just as much thrust on the wall as does the backing behind it, while the overturning tendency of the former is even greater, as its lever arm is ½ AC while the lever arm of the other is ⅓ AC. When the bottom is very soft mud of considerable depth and a pile foundation is to be resorted to, the normal difficulties of sustaining a retaining wall are so great that it becomes highly desirable to avoid the additional thrust due to the surcharge. In such cases a platform may be built extending from A to D, Fig. 13, and supported on an independent foundation sufficient to carry the surcharge, thus relieving the wall of the thrust due to W.

Precisely the same method as discussed in the above cases is to be used when the backing consists of more than two different kinds of material. Figs. 15 and 16 show such a case. The division planes between the different kinds of the backing are B_1M_1, B_2M_2, B_3M_3, and so on, while AMA_1N is the surcharge. The total pressure, from Fig. 16, is the area represented in that diagram. The triangular portions are the different pressures of the immediate backing and their sum is

$$S = \tfrac{1}{2}\,[w_1h_1^2 \tan^2\theta_1 + w_2h_2^2 \tan^2\theta_2 + \ldots\ldots w_rh_r^2 \tan^2\theta_r] = \tfrac{1}{2}\,\Sigma\,[wh^2 \tan^2\theta] \qquad (20)$$

The remainder of the diagram represents the pressures due to the uniform intensities af, b_1f_1, b_2f_2, etc., the values of which are found as under Case 3. The sum of these pressures is:

$$w_0h_0h_1 \tan^2 \tfrac{1}{2}(90^\circ - \phi_1) + (w_0h_0 + w_1h_1)\, h_2 \tan^2 \tfrac{1}{2}(90^\circ - \phi_2 + \ldots\ldots + (w_0h_0 + w_1h_1 + \ldots + w_{r-1}h_{r-1})\, h_r \tan^2 \tfrac{1}{2}(90^\circ - \phi_r) \qquad (21)$$

The expressions in the parentheses indicate the weights of the surcharges corresponding to the heights $h_1, h_2, h_3, \ldots h_r$. Denoting these by $W_1, W_2 \ldots W_r$ the expression for the total pressure found by adding Eq. 20 and 21, becomes

$$P = \tfrac{1}{2}\,\Sigma\,[wh^2 \tan^2 \tfrac{1}{2}(90^\circ - \phi)] + \Sigma\,[Wh \tan^2 \tfrac{1}{2}(90^\circ - \phi)] = \Sigma\, h \tan^2\theta\,(\tfrac{1}{2}\,wh + W)] \qquad (22)$$

The graphical method for finding P is shown in Fig. 15. Here P_1, P_2, P_3, etc., are respectively the pressures on AB_1, B_1B_2, . . . $B_{r-1}B_r$, due to the prisms $AB_1D_1E_1$, $B_1B_2D_2E_2$, $B_2B_3D_3E_3$,

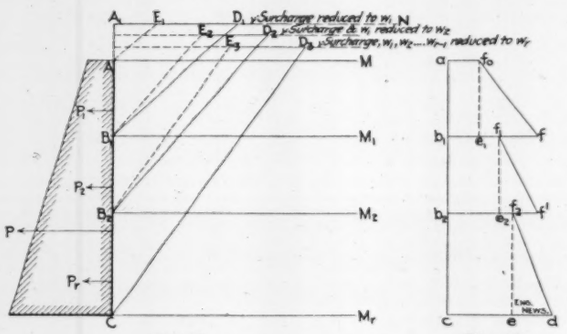

Fig. 15.

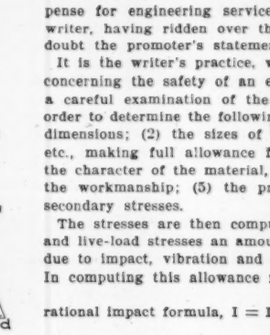

Fig. 16.

etc, while the point of application B of the resultant pressure is found by taking moments about an axis through C. The intensity of horizontal pressure at any point R within the backing where the constants are w_r and ϕ_r is:

$$P = (W_{r-1} + w_r h_r) \tan^2 \theta_r \qquad (23)$$

The method and formulas given in the preceding article were worked out by the author in 1902-1903, while he was connected with the Department of Docks and Ferries of the City of New York. A brief reference to the method was made in a paper on Pier and Bulkhead Construction in New York Harbor, published in Engineering News of May 18, 1905; a diagram there given to show its application is, however, inaccurate in several respects.

CONCERNING THE INVESTIGATION OF OVERLOADED BRIDGES.*

By Wilbur J. Watson,† M. Am. Soc. C. E.

For some years a large part of the writer's professional work has been the investigation of existing bridges which are subjected to loads greater than those for which they were originally designed; and, in the course of this work, he has found, among bridge engineers, such a divergence of views regarding the maximum unit stresses, etc., which may be safely allowed in an existing structure, that he takes this opportunity of bringing the matter before the society for discussion, in the hope that thereby greater uniformity of opinion may be established. The rapid development of electric traction lines, both urban and interurban, many of which are built upon highways, has had the effect of overloading many highway bridges.

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The writer has in mind an interurban line which was built upon a highway and crossed many bridges. The engineer in charge, who was not a bridge engineer, reviewed the stresses caused by the new loading, and condemned every structure in which they exceeded the recommended by a certain standard specification for highway bridges. On the other hand, lines have been built over old highway bridges without any investigation whatever being made as to the strength of the bridges. It is hardly necessary to state that such lines were built by promoters, without the aid of competent engineers.

One promoter, desiring to show his contempt for engineers in general, told the writer that he had built an interurban line 10 miles in length, and that his total expense for engineering services amounted to $75. The writer, having ridden over this line, sees no reason to doubt the promoter's statement.

It is the writer's practice, when called upon to report concerning the safety of an existing structure, to make a careful examination of the structure in the field in order to determine the following points: (1) The general dimensions; (2) the sizes of the members, connections, etc., making full allowance for corrosions, if any; (3) the character of the material, whether steel or iron; (4) the workmanship; (5) the presence of, or liability to, secondary stresses.

The stresses are then computed, and to the dead-load and live-load stresses an amount is added to cover those due to impact, vibration and similar secondary stresses. In computing this allowance for secondary stresses, the rational impact formula, $I = L \frac{L}{L + D}$, is used, in which I equals the allowance to be made for secondary stresses, L, the stress due to the live load considered as a static load, and D, the stress due to the dead load only. In case there exist secondary stresses due to eccentric connections, which are very common in old highway bridges, or due to other defects in design or execution, these should be added to obtain the maximum.

In regard to allowable unit stresses, it may be stated, as a general principle, that the greatest possible stress in any member should not exceed the elastic limit of the material.

There are two reasons why this limit has been used: (1) In exceeding the elastic limit, the stress causes a permanent distortion of the member, which, in turn, causes a change in the conditions which were assumed in computing the stresses; (2) the classical experiments of Wöhler and Bauschinger demonstrated that repeated strains greater than the elastic limit of the material, but much less than the ultimate strength, might cause rupture.*

It is well known that eye-bars and built-up members do not develop the full strength indicated by their sections and by tests on small-sized pieces, and it would appear that it is not safe to assume the elastic limit of full-sized members to be more than about 75% of the elastic limit indicated by tests on small test pieces of the material of which these members are composed. It has also been demonstrated that single angles, connected by one leg only, cannot be depended upon to develop more than about 80% of their computed strength.†

The second cardinal principle, then, as used by the writer, may be stated as follows: The greatest computed unit stress in any member in tension, making full allowance for ordinary and extraordinary secondary stresses, should never exceed 75% of the elastic limit of the material for members symmetrically connected, nor 6[illegible]

*Paper by H. B. Seaman, M. Am. Soc. C. E., on "The Launhardt Formula, and Railroad Bridge Specifications," and discussion thereon by C. C. Schneider, M. Am. Soc. C. E., Transactions, Am. Soc. C. E., Vol. XLI, pp. 140 and 173.

†Paper by J. E. Greiner, M. Am. Soc. C. E., on "Tests of Bridge Members," Transactions, Am. Soc. C. E., Vol. XXXVIII, p. 41.

TABLE 1.—STRESSES IN STRINGERS AND FLOOR-BEAMS OF RAILWAY BRIDGES.

(Full allowance has been made for impact, etc., by the use of the impact formula, $I = L \frac{L}{L + D}$. All these stresses were obtained from the wheel-loads actually used.)

No.	Railroad.	Member.	No. of members.	Flange unit stress. lbs.	Maximum rivet-bearing on web. lbs.	Material.	Examined in:	Replaced in:	Remarks.
1	Railroad	Stringers	..	18,300	45,000	Iron	1901	.....	In use, 1905
2*	.....	"	32	10,200	39,000	"	"	"	"
3*	.....	"	4	9,500	52,400	"	"	.....	" "
4	.....	"	8	19,100	49,100	"	"	.....	" "
5	.....	"	..	15,500	38,000	Steel	1900	1903-04	
6	.....	"	..	27,000	31,000	"	"	"	
7	.....	Deck-span	..	16,700	28,800	Iron	"	"	
8	.....	"	..	21,400	35,600	"	"	"	
9	.....	"	..	23,500	37,000	"	"	"	
10	.....	Floor-beams	..	16,000	38,000	"	"	"	
11†	Traction Co.	"	..	23,300	33,100	Steel	1903	.....	In use, 1905
12	"	"	..	23,050	38,300	"	"	"	" "
13	Railroad	Stringers	..	18,700	37,700	Iron	1902	.....	Not known, if in use now.
14	"	"	..	25,600	45,800	"	"	.....	"
15	"	Floor-beams	..	20,600	43,000	"	"	.....	"
16	"	Stringers	12	23,200	42,400	Steel	1900	1904-05	
17	"	Floor-beams	5	21,000	35,700	"	"	"	
18	"	Stringers	..	19,520	36,700	"	"	"	
19	" Trunk line.	"	..	29,800	52,300	"	"	"	
20	"	Stringers & floor-beams	70	20,000 (av.)	40,000 (av.)	Iron	"	.....	Still in use. 1905

*Nos. 2 and 3 were old stringers cut off and used as deck spans, which accounts for the great disproportion between the flange unit and the bearing stresses of the flange rivets.

of the elastic limit of the material for angles connected by one leg only. The latter case is very often found in old lattice trusses. This would give, for symmetrically connected members in tension, working stresses of, approximately, 20,000 lbs. per sq. in. for iron, 24,000 lbs. per sq. in. for soft steel, and 26,000 lbs. per sq. in. for medium steel.

In examining old bridges, it is necessary to note carefully the construction of the compression members, as these are often insufficiently stiffened, especially the T-sections formerly used to such an extent. The writer will make the statement, drawn entirely from personal knowledge, that more failures occur in compression members than in tension members, and he has in mind the failure of an electric railway bridge by the buckling at the top chord (a T-section) under a unit stress in the steel not exceeding 22,000 lbs. per sq. in. Full allowance for impact, etc., as outlined above, had been made, and the failure was entirely due to the lack of proper stiffening of the member.

It is the writer's practice to increase the stress in compression members by the following formula, $S_2 = S_1\left(1 + \frac{l^2}{18{,}000\,r^2}\right)$, in which S_1 = the direct unit stress, S_2 = the maximum unit stress, l = the length of the member, and r = the radius of gyration of the member, in inches. This will be recognized as Gordon's formula as ordinarily used for pin-connected columns.

For computing the stresses in an improperly designed column, no general method is offered, as it is governed by the peculiarities of each case. It is in cases such as these that good engineering or structural judgment is most needed.

Many structures are unnecessarily condemned on account of rivets overstressed in shearing and bearing. The usual assumptions governing such cases are as follows: (1) That the shearing strength of the material is equal to two-thirds of the tensile strength, and that the bearing strength is equal to twice the shearing strength; (2) that the entire stress transferred from one member to another must be considered as transferred entirely by the rivets in shearing and bearing, making no allowance whatever for the friction between the surfaces of the members; (3) that the diameter of the rivet is assumed as the diameter before driving.

These assumptions would give maximum allowable stresses for iron rivets of, approximately, 13,300 lbs. per sq. in. in shear, and 26,000 lbs. per sq. in. in bearing. The writer's experience has convinced him that riveted connections will not fail under any such limits of stress, and, in general, rivets will not begin to work loose until the unit stresses are nearly twice as great as these.

Table I. gives some of the unit stresses in bearing of the flange rivets of built-up stringers of railway bridges examined or computed by the writer. All these bridges were on railroads carrying heavy traffic, and, in computing the stresses, full allowance was made for impact, etc. Not one of these stringers, as far as the writer is aware, ever showed signs of failure. The tensile unit stress is also shown, by way of comparison with the bearing stress.

The writer has considered that the reason for this great discrepancy between theory and observed results lies in the neglect of the element of friction between the two faces of the members in contact. This theory seems to be confirmed by the results of such tests as have been made.

Tests to determine the friction of riveted joints were made at the Watertown Arsenal, in 1882. These demonstrated that the friction developed between the surfaces of the plates of a riveted joint is a function of the area of the rivet section, and, therefore, is directly comparable with the shearing value of the rivet. These tests show the value of friction to be about 14,000 lbs. per sq. in. of rivet section for the single surfaces in contact, for a lap-joint, and about 18,000 lbs. per sq. in. for joints providing two contact surfaces. As these values are higher than those usually allowed for rivets in shear, it follows that, in riveted joints, the working stresses are transmitted entirely by friction, and the shearing and bearing resistances of the rivets are not brought into play until much higher values of stress are reached.

It would appear that the ordinary working values of rivets in shear and bearing might well be increased, in the design of new work, and that the maximum allowable stresses in old structures might also be increased.

European bridge engineers have stated that European practice allows a much higher value of rivets in shear and bearing than American practice, and that they have never had trouble from this source. Therefore, it is perfectly safe to allow shearing and bearing values equal to the allowed value of the material in tension for shear, and, to double this amount for bearing, provided there are enough rivets in the connection, and that the workmanship is such as required to develop friction between the surfaces of the material. This would give values of, approximately, 22,500 lbs. per sq. in. in shear, and 45,000 lbs. per sq. in. in bearing, for rivet steel having a minimum elastic limit of 30,000 lbs. per sq. in., to be used in examining old structures.

A set of experiments on riveted joints was recently made for a committee of the American Railway Engineering and Maintenance-of-Way Association.* These experiments were made on 90 small riveted test pieces, which were tested to destruction, the failure occurring, in a majority of cases, by the shearing of the rivets at unit stresses of from 45,000 to 50,000 lbs. per sq. in. of rivet section before driving, or by the breaking or splitting of the plates.

The values of the rivets in bearing upon the plates were approximately twice the shearing values at the point of failure. The conclusions drawn by the committee are repeated here:

(1) That the resistance of a riveted joint against deformation by shearing forces, up to the yield point, is due to the friction between the surfaces held in contact by the rivets.

(2) That the yield point of a riveted joint is reached when the shearing forces are equal to the friction of the surfaces held in contact by the rivets.

(3) That the deformation of a riveted joint at the yield point is caused by the slipping on each other of the surfaces held in contact by the rivets, and is due to the diametral contraction of the rivets in cooling after they are driven, which leaves a space between the body of the rivet and the edge of the rivet hole.

(4) That after the slip at the yield point has occurred and the rivet is brought to bear against the edge of the rivet hole, a deformation of the body of the rivet takes place with an accelerating increase in the resistance until the entire side of the rivet has been brought to bear against the edge of the rivet hole, and that the deformation continues beyond this point with a diminishing increase in the resistance until the ultimate strength of the rivet in shear has been reached and the breakdown occurs.

(5) That lap joints, on account of the unsymmetrical distribution of material, deflect sideways under strain, throwing the rivets in tension, and thereby reducing the shearing forces between the surfaces held in contact by the rivets.

(6) That fillers inserted between the main plates reduce the strength of a riveted joint, but that the full strength can be obtained by connecting the fillers to the main plates by additional rivets.

(7) That the number of rivets connecting the fillers to the main plates should, for each intervening filler, be about one-third the number of rivets required in a similar joint without fillers, to obtain the same strength in both cases.

(8) That the strength of a riveted joint with rivets of larger grip than about four times their diameter is decreased, as the length of the grip is increased.

(9) That the number of rivets, in a riveted joint with larger grip of the rivets than four times their diameter, should be increased at least 1% for each one-sixteenth of an inch increase in the grip above this length, to obtain the same strength as a similar joint with the grip of the rivets shorter than four times their diameter.

(10) That a riveted joint, subject to forces always acting in the same direction, may safely be strained beyond the yield point up to a point where the rivets are brought to bear against the edges of the rivet holes.

(11) That a riveted joint subject to forces alternating in opposite directions, may not safely be strained up to the yield point.

(12) That, to obtain a minimum slip at the yield point, it is necessary that the holes in the component pieces should thoroughly match, and that the driving tool should upset the rivet throughout its length so that it will thoroughly fill the rivet hole.

If the third conclusion be true, that rivets, in cooling, contract to such an extent that a space is left between the rivet surface and the side of the rivet hole, why is it that all rivets do not test loose under the inspector's hammer? It is the firm conviction of experienced inspectors that they can detect any rivet that is not completely upset. Is it possible that these men are mistaken, and that rivets which test loose do so only because the grip of the rivet heads on the plate is not great enough to prevent their movement?

This theory has been advanced before by European engineers, but the writer has seen specimens of riveted joints, which, when sawn through the rivet and polished, showed only a fine hair line dividing the rivet surface from the sides of the hole, which indicated a perfectly tight rivet. Of course, as is well known, in the case of long rivets, they are entirely upset only at the ends, and a space is often left between the rivet surface and the side of the hole at the center of the shank. Furthermore, the writer is loath to believe that the many thousands of rivets which he has tested and found to ring true could have done so unless the rivet sides were in contact with the sides of the hole, at least for some distance under the head.

Cannot the slipping of the plates, at the stress which is sufficient to overcome the friction between their surfaces, be explained on the ground of the compressibility of the metal, since apparently the slipping always occurs at a high stress? The experiments of M. Considère, in France, indicate slipping at a stress equal to approximately four-tenths of the ultimate shearing strength of the rivets, while the records of the experiments conducted by the committee referred to, do not indicate any extraordinary movement of the plates when the slip occurred, subsequent increments of load causing movements of the plate comparable to the original slip. Is it not probable that the driving operation causes a state of compression to exist in the rivet metal and in the surrounding plate sufficient to take up the contraction due to cooling?

When the stress becomes sufficient to overcome the friction between the plates, the sudden reduction of the coefficient of friction would bring about half this stress suddenly upon the rivets, and considerable movement would be expected, due to the compression of the material, even if the rivets were perfectly tight.

There is another point, which concerns the design of new work as well as the investigation of old work, to which attention should be called.

In the design of plate girders it is the general custom, in the United States, to take the effective depth of the girder as the distance between the centers of gravity of the flanges, when obtaining flange stresses, and the distance between the rivet lines as the effective depth when obtaining the rivet values, which are dependent upon the stress transferred from the webs into the flanges in a given distance. Since the latter stress is simply an increment of the former, it would seem inconsistent to use different depths of girder for the two cases. Would not the more rational method be to assume the effective depth of the girder as variable, and use the same depth for both purposes?

At the ends of the girder there is no flange stress, and, therefore, the effective depth of the girder is evidently the distance from center to center of rivets, while at the center of the girder, considering the same to be uniformly loaded, there is no shear, and all the stress has found its way into the flanges. Evidently, then, the distance between the gravity lines of the flanges is the correct depth of the girder at this point, if the stress be uniformly distributed throughout the flange section, as it seems reasonable to assume.

The writer has found many cases of existing girders in which the maximum rivet stresses were found, not at the ends of the girder, but at an intermediate point; and he would recommend that, in such cases, a depth intermediate between the distance from center to center of gravity of the flanges, and the distance from center to center of the rivet lines, be taken as the effective depth for all purposes.

There is another point which illustrates well the difference between rules for designing new structures, and those for investigating old ones.

It is common practice, in designing plate girders, to allow no part of the web to be considered as flange section. While this gives an added factor of safety to the structure, and may be commendable in designing new work, there can be no doubt but that the web will do its share of the work involved in resisting flange stresses, in spite of the prohibition, and this fact should be fully considered in determining the strength of an existing structure, as, in such cases, it is desirable to know the actual conditions of stress.

The writer is a firm believer in the use of standard specifications as a guide in designing standard structures, and believes just as firmly that they should not be followed in designing structures which are of an extraordinary or unusual nature, and should not be used when reporting upon the safety of a structure, which is, in itself, unusual, or is subjected to unusual conditions of loading.

The general principles of bridge design should constitute the engineer's sole guide in such cases, and his only purpose should be to determine the actual conditions of stress in the various parts of the structure, basing his computations on actual measurements, and "rock-bottom" principles, unhampered by the limitations and assumptions of a set of specifications gotten up for an entirely different purpose.

*Bulletin No. 62, American Railway Engineering and Maintenance-of-Way Association, April, 1905.

THE RAILWAYS OF INDIA aggregated 28,295 miles at the end of 1905; during that year 749 miles were opened and 627 miles authorized. On the entire railway system there were 15,028 miles of 5 ft. 6 ins. gage, 11,959 miles of meter gage, 980 miles of 30 ins. gage and 328 miles of 24 ins. gage. Interlocking apparatus was installed at 180 stations, while 79 stations were provided with automatic instruments for signaling trains between stations. The equipment comprises 5,815 engines, 20,202 cars in passenger service and 111,024 cars in freight service; of these, 3,016 engines, 11,201 passenger cars and only 3,798 freight cars are equipped with automatic brakes. Of the passenger cars, 9,782 are fitted with gas light and 648 with the electric light. Standard time was adopted on all the railways on July 1, 1905; in India it is 5½ hours in advance of Greenwich (London) time, while in Burmah it is 6½ hours in advance. As a result of recommendations made by Mr. Thomas Robertson, after a careful investigation of railway affairs in India, the government has abolished the railway branch of the Public Works Department and has placed the control of the railways in the hands of a railway board, consisting of three members. Most of the rolling stock and other railway material has been purchased in England, but several manufacturers in India have asked for the opportunity of bidding for the construction of freight cars, and it has been decided that in future proposals for 25% of cars ordered will be advertised in India. The wheels, axles, springs, draft gear, etc., will still be obtained entirely in England, and will be supplied to Indian firms who are awarded contracts for frames and bodies.

HEATING AND VENTILATING SYSTEM OF THE LOUISVILLE & NASHVILLE DEPOT, LOUISVILLE, KY.

By Richard C. Williams, M. E.*

The installation of an indirect heating and ventilating system recently completed in the new Louisville & Nashville depot at Louisville, Ky., is of interest because of the installation of an air washer. The washer effectually removes from the air all solid matter in suspension, as well as undesirable gases, which are necessarily present in the vicinity of a large railroad station. After the air has been washed the free moisture is removed by the eliminator.

The air inlet to the ventilation system is through a 3½ × 6¾-ft. air shaft, running to the top of the building. The air then passes one two-row and two four-row 7 × 8½-ft. tempering coils, containing 2,400 ft. of 1-in. pipe, which serves to heat the incoming air in cold weather to 50° or 60° F. before it passes on to the air

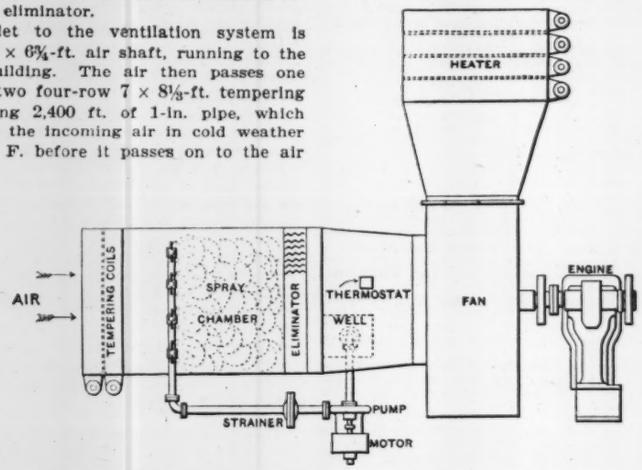

FIG. 1. SKETCH OF BUFFALO AIR WASHER AND HUMIDIFIER, SHOWING RELATIVE POSITION OF NOZZLES, ELIMINATOR, ETC.

washer. From the washer the air is divided, each portion passing through a set of heating coils containing 4,050 ft. of 1-in. pipe, thence to a 100-in. three-quarter housing blower, which is 71 ins. wide. The discharge of each fan passes through a heater coil of 1,440 ft. of 1-in. pipe into a plenum chamber, whence it is led by galvanized iron ducts to the many diffusers placed around the building. Fig. 1 is a diagrammatic sketch showing in plan the relative positions of nozzles, eliminator, etc.

The air washer and humidifier was installed, as it was considered to be more practical than the usual type of coke screens or cloth filters, as far as thoroughness in performing the work and space occupied were concerned, and also in regard to the first cost of installation and maintenance expense. Coke screens, and in particular the cloth filters, have been found in practice to require frequent renewal and an annoying amount of attendance, while the air washer is automatic in action.

The air washer provides for keeping the relative humidity at a constant percentage of the saturation point, irrespective of the condition of the air drawn in through the grating.

The washing is accomplished by sprays of water atomized from 171 specially designed nozzles, placed in a sectional area of conduit 7 ft. 10 ins. wide by 9 ft. high, in which the atomizing action is obtained by a rotative action given the water by the nozzle. So successful is this method that the spray is barely visible. The projection of the water is in the direction of air travel, so that completeness of washing is assured with varying velocities of the air. The water is supplied to the nozzles by a belt-driven centrifugal pump. It may be interesting to note that as each nozzle delivers about 1½ lbs. of water per min., a total of over seven tons per hour is used to wet down the entering air.

After being washed, air next passes through the eliminator, as it is termed. This is an essential feature of the outfit, consisting of a system of vertical baffle plates so arranged as to remove the free moisture from the passing air, while allowing it to retain an amount sufficient for the proper regulation of the humidity. The first portion of the baffle plates presents to the air merely a water film, contact with which effectually removes every trace of solid matter that may have been present originally in the air. The second portion of the plates include gutters running the length of the plates to prevent the water being blown from the farther edge by the velocity of the air. These break the continuity of the water film on the first portion and serve to remove the free moisture. Fig. 2 is a diagrammatic sketch showing the eliminator plates in plan. By test it has been found that the resulting back pressure caused by the interposition of these baffle plates is less than 1/16-in. water pressure. To prevent the possibility of rust these baffle plates are made of galvanized iron, and are therefore non-corroding. The water from the gutters in the baffle plates runs to a settling tank built in the concrete foundation for the washer, and on which the washer is supported by galvanized I-beams. The cleaner water is drawn off to a well with which the suction of the pump supplying the nozzles is connected, and hence the water is used over and over again, the level in the settling tank being maintained constant by means of a float valve connected to the supply mains. All water passing the pump is passed through a strainer before being returned to the nozzle, while the nozzles are readily taken apart by hand to remove any scum or deposit that may collect there.

A thermostat located between the baffle plates and the blower is adjusted by trial until the proper percentage of humidity is obtained, after which its action is automatic. The function of the thermostat is to regulate the temperature of the spraying water, when the temperature between the fan and the eliminator plates changes. This method of regulation was adopted after experiments which showed that the amount of moisture absorbed by the air was more dependent on the temperature of the spray water than upon the temperature of the air. The control of the water temperature is through a steam jet, connected with the thermostatic motor.

Fig. 2. Diagrammatic Sketch of Eliminator Plates.

The washer and eliminator are housed in heavily galvanized iron, stiffly braced, riveted and soldered water-tight. A door is provided with a water-tight gasket and a panel arranged for a plate glass window to allow inspection of the washer during operation.

Another serviceable use of the washer, during the summer months, is to cool the air admitted to the building. In this capacity it is guaranteed that the final temperature difference between the spray water and air will not exceed 20% of the initial difference of temperature, when considered at the rated capacity of the washer.

The heating and tempering coils, air washer and humidifier, etc., were furnished by the Buffalo Forge Co., of Buffalo, N. Y.

*With the Buffalo Forge Co., Buffalo, N. Y.

A NEW EXPERIMENTAL METHOD OF DETERMINING THE LOCATION OF THE NEUTRAL AXIS IN REINFORCED CONCRETE BEAMS.

By F. D. Warren.*

All methods heretofore adopted for locating the neutral axis of beams have been based upon either (1) A series of deformation readings taken by extensometers, within a given length, on two horizontal layers the distance between which is known, or (2) Upon computations to satisfy an assumed stress-strain diagram. The first method is based upon the assumption that a section plane before bending remains plane after bending; the latter, that the compressive stress above the neutral axis varies either uniformly (represented by a straight line) or as the ordinates of a parabola, or as the ordinates of some modified curve between a straight line and a parabola, while the tensile stress below the neutral axis varies as a straight line or as a compound curve.

The new method suggested in the following, is, unlike the others, a direct method of locating the neutral axis, and is governed by accepted laws of Mechanics, as the description below will demonstrate.

Two vertical groups of attachments or clips are secured into the side of the beam; the two groups are separated a distance of 30 to 50 ins., the test-length. The two groups contain equal numbers of attachments, arranged to lie in the same horizontal planes. The attachments of one group may be simple hooks, while those of the other group are take-up devices similar to those used for piano strings. The successive horizontal pairs (each comprising a hook and a take-up) are spaced say 1 to 1½ ins. apart vertically, but may be closer together as desired or found necessary. In the horizontal line of each pair, at two or more points spaced equidistant between hook and take-up, a pin or other simple form of support projecting from the side of the beam is provided. Piano wires are stretched horizontally between the end attachments and drawn under the intermediate supports, the same gage of wire being used for all horizontal strings. The several wires are then tuned into common pitch with a tuning-fork.

The beam is then loaded, in such a way as to produce uniform bending moment over that section of the beam covered by the test-device. After each increment of load, all wires are tested for pitch, being compared with the tuning-fork by which they were originally set; the difference in pitch between each string and the tuning-fork is noted, as closely as it can be fixed by the ear. Wires on the compression side of the beam will evidently shorten, and therefore become lower in pitch, while those on the tension side will rise in pitch. That wire which corresponds to the neutral axis of the beam will not change in pitch, since the neutral plane is defined as the plane along which there is no longitudinal deformation. By locating this wire with the help of the tuning fork, the position of the true neutral axis is directly determined.

The object in employing intermediate supports between the end attachments of the wires is to cause the wires to follow a series of chords of the deflection-curve of the beam, and so reduce to a negligible amount the error of measuring the length of the chord instead of the arc. The greater the number of intermediate supports,

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the more clearly is this realized, and the better are the results.

It is necessary in this method, just as in the method using extensometers, to employ such a type of loading as will give uniform bending moment along the test-length, because otherwise the measurements will refer to average conditions over a range of variable moment. It is known that the neutral axis shifts its position as the bending moment changes, and it follows that the horizontal trace of the neutral plane in a loaded beam, where the moment varies from point to point along the beam, is not a line parallel to the geometrical center line of the beam, but is curved with respect to this center line. The plano-wire method, and also the extensometers, will merely give the position of a line which averages this curve over the test-length, and it is therefore necessary, when finding the location of the neutral axis, to convert the latter into a straight line along the test-length by maintaining the bending-moment at all times uniform along this length.

The author has tested two reinforced concrete beams by this method, with satisfactory results. From these two tests it appeared that the location of the neutral axis may be divided into distinct stages, as follows: During the first, before the effect of the steel comes into action, when the beam may be considered as a plain concrete beam, the location appears to be at or near the center of the depth. During the second, the neutral axis lowers until all the tension is resisted by the steel; during the third, the location remains practically constant and continues until the elastic limit of the steel is reached; finally, during the fourth stage, the location rises rapidly, while the steel is stretching, until fracture occurs by the ultimate crushing of the upper fibers. It is not expected that the results of two tests should be conclusive proof of the behavior of all specimens, but they are given merely as illustrations, with which future tests may be compared.

THE STORAGE OF COAL BY SUBMERGENCE IN SALT WATER.

Coal storage under water was briefly discussed in our issue of July 5, 1905. A more detailed consideration of the subject, which is in general accord with the ideas expressed by this journal, may be found in a recent number of the Proceedings of the United States Naval Institute (Vol. XXXII., No. 2). There Capt. W. H. Beehler,* U. S. N., says, in part:

The great expense and anxiety due to fires in coal sheds makes the advisability of submerged storage for coal very important. At Key West and Dry Tortugas, Fla., 35,000 tons of coal have been stored in four large steel coal sheds—two at each place—with about 6,000 tons in four old wooden coal sheds. The coal in these four steel sheds has been stored at depths varying from 20 to 35 ft., and this pressure has necessarily generated fires in the coal.

It seems that the pressure of the weight of the coal causes gases to be evolved, especially in little pockets where lumps of coal bridge over air spaces. The air in these small pockets causes combustion of the gas there, and the fine coal around them is probably fused to form an arched furnace. As this proceeds the coal is coked and the furnace gradually enlarges. Smoke and gas escape through crevices in the coal and form the only indication of the existence of such pockets of fire in the mass of the coal. When coal is placed in the shed the big lumps fall down to the sides, and these big lumps bridge over air spaces, where the pockets of combustion have always been found.

There is no doubt that water will always extinguish a fire, provided the water can be applied at the site in sufficient quantities. The old idea that water caused spontaneous combustion has been thoroughly exploded. Chemical decomposition might be caused by fresh water, in that fresh water will dissolve some vegetable matter, and those chemical solutions thus formed may contribute somewhat to the formation of solutions that would cause fire; but this cannot be true of water in contact with coal. Salt water will not dissolve coal and liberate the gases that would develop heat. There is no possibility of spontaneous combustion from water, whether in minute or large quantities. Water will extinguish coal fires, and coal kept in water cannot burn until the water is removed. If the coal is kept under water, it is evident there will be no combustion of the coal.

Indications here at Key West point out very clearly that it will be of great advantage to have coal stored under salt water. There is no reliable data of a scientific character to demonstrate that fact from the experience here at Key West, but coal that had dropped from thee coal sheds into the sea water around the coal sheds has been removed and consumed in the boilers of the distilling plant. It is not known how long this coal had been submerged under salt water, and the only point positively ascertained was that the coal did seem to burn better in the boilers of the distilling plant than similar coal which had not been submerged. This was only the opinion of the firemen at the boilers. There were no accurate measurements taken as to the combustion of this coal, the heat units evolved, the products of combustion, and comparative value; but it was evident that this coal, after having been submerged for at least a year, was as good as the coal which had recently been brought here. No deleterious effect was observed upon the boilers by the use of this coal which had been a long time submerged in sea water. Moreover, the coal in the coal sheds has been saturated with water, and from all that can be ascertained, this coal has not been in any way injured by having been saturated with salt water.

*Commandant U. S. Naval Station, Key West, Fla.

Fires generate here in the tropics from coal every winter. It is claimed that if a ton of fine bituminous coal be spread out on a concrete pavement and exposed in open air in this climate for one year, it will lose all its calorific properties. The gases are simply free to evaporate from the coal, and when the coal has lost all its gas it will have lost all its heat units and be simply coke. In a coal pile, the top surface of the coal in this climate becomes practically burned out. The gas from the upper layer has been free to exude or evaporate by the action of the sun and the atmosphere, and it is only because the upper layers of coal cover the mass that the mass retains any of its heat units. From this it is evident that if covered by salt water the gases cannot escape from the upper layers. All the gases will be practically retained in the mass of coal. There is no loss of heat units while stored under water.

Salt water storage will obviate all loss of coal due to dust. The fine coal dust will not be blown away, and it is a very conservative estimate that at least 50 to 100 tons of coal have been lost in the shape of dust in handling 15,000 tons of coal in one year at Key West Naval Station.

During the past six months I have been making a careful study of this subject, and I have recommended that the steel coal sheds be converted into concrete water-tight cisterns, having the same coal hoisting machinery as at present, but merely lined with concrete walls, with sloping sides, and inverted pyramidal bottom, fitted with drain-pipes at the bottom to drain off the water when necessary, and also to have means to flood it with water. Such a water-tight concrete cistern would store the coal, and should have no dangerous ventilating pipes or other aids to combustion. By having an inverted pyramidal floor the grab buckets could be used to remove all the coal without hand labor to load skip buckets.

The advantages of such a water-tight concrete coal shed are as follows:

(a) The submerged storage of coal therein will hermetically seal the gases in that coal.

(b) Small pockets of combustion cannot be formed with coal under water.

(c) The gases cannot be evolved from coal under water.

(d) The pressure upon the particles of coal at different depths will not be so great. The pressure at the bottom will not develop heat, because the pressure in a reservoir of water 50 ft. deep does not generate any heat at the bottom of that reservoir by the weight of the superincumbent mass of water.

(e) Fires in coal stored under water are impossible.

(f) The expense of fighting fires during the past ten months at Key West would more than defray the cost of converting a shed into a concrete water-tight cistern as proposed.

(g) The evolution of gases in the sheds at present has a very deleterious effect upon the steel work and makes it necessary to paint these sheds much more frequently than iron and steel structures are otherwise required to be painted.

(h) Such submerged storage will obviate the loss of coal by fire.

(i) Coal so stored will be delivered damp, and there will be no loss of coal dust carried away by the wind.

(j) In such a concrete water-tight cistern the wet coal will not come in contact with any steel work, and there will be no corrosive action upon steel work by the salt water.

(k) In fighting fires at present, streams of salt water are poured in upon the fires, and this salt water has a very deleterious effect upon the steel framework of the shed.

(l) It could easily be arranged that shortly before delivery—one or two days, perhaps—the water could be drawn off from the upper part of the coal shed so as to deliver the coal without water, when the coal would simply be damp, and not dusty.

The foregoing advantages of submerged salt water storage appear to me to be incontestable, and the disadvantages are merely supposed deleterious effects of salt water and difficulty in drying coal that has been long saturated with salt water.

It is claimed that wet coal will injure the bunkers of ships, but the Navy Department has recently authorized wet coal to be delivered to ships, and therefore this objection cannot be sustained. Coal is just as wet from water used in extinguishing fires as it would be if kept constantly submerged under salt water, and the objection of having wet coal in the bunkers can be ignored. The very slight corrosive action of damp coal in the bunkers of the ship is of no importance compared with the exposure of the outer skin of the hull of the ship floating in salt water.

The effect of burning coal pickled in brine in the furnaces of modern boilers may possibly be injurious to the tubes; but that effect, at the worst, can only be slight, and it is exceedingly doubtful if the products of the combustion of such coal which had been for years stored under salt water could have any deleterious effect on the boiler. It would take many years for coal submerged under salt water to have such quantities of chloride of sodium or other chemicals as to be injurious in a boiler.

Regarding the reports that the German Navy Department had recently concluded a series of experiments, covering a period of two years, which showed that the heating value of Westphalian coal was considerably reduced by being stored under water, while if stored in a shed it was but slightly affected, Captain Beehler, in another place, says:

I know from my personal observations, that such experiments, conducted by the German Navy Department, are always most accurately executed.

In these German experiments, a comparison was made with 12,000 kilograms or 12 tons of coal stored on land under cover, and 12,000 kilograms, or 12 tons, stored in sea water. It is not stated exactly how the coal was so stored, but presumably cubical tanks, 8 ft. cube, of about 500 cu. ft. capacity, were used. It is evident that there was nothing like the pressure in these tanks from the weight of the coal, as in the case where coal is stored in piles 20 ft. deep.

The results obtained by this experiment with 12 tons of coal cannot be regarded as applicable to coal piles of 1,000 tons and over, because the pressure of the weight of coal makes the problem totally different. In large coal piles the pressure is enormous, and so great that fires are generated by the heat evolved by this pressure. The heat developed in a small coal pile is so slight that fire insurance companies will insure piles 9 ft. or less in depth, but they deem the risk too great to insure any coal stored in piles deeper than 9 ft. The German experiments, with only 12 tons of coal, therefore could not have had pressure comparable with the coal stored 20 to 30 ft. deep.

At Key West, in Coal Shed B, last winter, the coal was stored in depths ranging from 20 ft. at the sides to 35 ft. in the center, and the heat evolved was so great that the steel plates on one side were red hot, and I had to get the tug and pumping barge out one night to play the hose on the outside of the shed, while seven streams of water, with patent and other long nozzles, were used within. This and all other fires, and the great heat almost constantly found in the coal sheds, give certain evidence that the coal is losing heat units. Surely, if submerged, this heat would not be evolved from the coal while the storage of large masses of coal, in piles over 9 ft. deep, must cause loss of more heat units when stored in air than when under water. The report of the German Admiralty experiments has ear-marks of being an irresponsible newspaper report, which should not be accepted as conclusive. The subject is new and further information is most desirable, especially as to the manner in which the coal was stored both in the shed on land and when under water. Particular stress should be laid upon the depth of the mass of coal in the experiments, to ascertain the pressure to which the coal was subjected, due to its own weight.

It is thus evident that there is not a consensus of opinion as to the value of storing coal under water. Experiments carried on by Mr. J. Macaulay, General Manager of the Alexandra Docks & Railway (Wales) showed that storage by submergence in water was superior to storage in sheds, while the report of the results of the German Navy Department experiment apparently disprove these conclusions. The final results of the experiments now being carried on by the British Admiralty will be awaited with interest, more so since the preliminary reports indicate the superiority of storage by submergence over storage in sheds.

SPARK INSPECTION DEVICE FOR INTERNAL COMBUSTION ENGINES.

A device to enable the electric ignition spark in internal combustion engines to be examined while the engine is running has recently been introduced, and it is claimed that the quality of the mixture used can also be gaged by inspecting the flame of the ignited gases. This device consists of a hard glass ball, placed between two body parts that are threaded, and the ball is packed with asbestos rings, which can be renewed in a few minutes. It is said that the peculiar property of the glass sphere is that it enables the spark to be readily inspected at some distance from the engine, which would not be possible if flat-surfaced glass was used. For engines working with town gas, without magneto, when the instrument is screwed into the indicator hole it enables the operator to judge the quality of the mixture he is using in the cylinder. It is claimed that in this way the use of the indicator is, to a large extent, dispensed with. A number have been in use for some months on engines of the highest compression, and without water-cooled spark-boxes, and it is said that in no case has there been failure from leakage or breakage of the ball. They have also been in use on air-

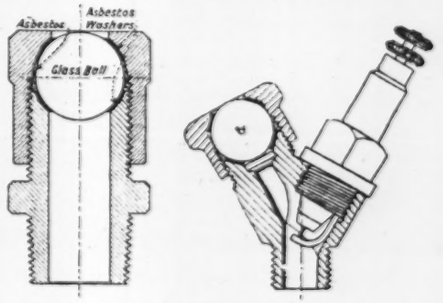

Fig. 1. Fig. 2.

Spark Inspection Device for Internal Combustion Engines.

cooled engines, running at nearly 2,000 revolutions per minute, with the same satisfactory results. Fig. 1 is a section of the device, and Fig. 2 shows it as adapted to be fitted to a sparking plug. The device is the invention of Mr. A. F. White, of Stroud, England, and our cut is reproduced from a recent article in "The Engineer," of London.

A SENSITIVE PORTABLE EXTENSOMETER.

A new type of micrometer has been designed and adapted to an extensometer which should be particularly useful for engineers. While extremely sensitive in its measurements, it is at the same time so compact and robust that it may be carried about in the pocket and requires only a few moments to adjust it for observation. Its use does not require laboratory facilities and its manipulation is unusually simple. As an extensometer for measuring strains or expansion, it is sensitive to the nearest 1-50,000 in., with a range of 200-50,000 in. An instrument made with a frame 20 ins. long will thus measure to one one millionth part of the length under observation;

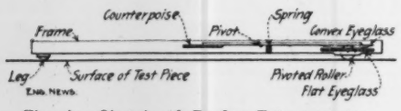

Fig. 1. Sketch of Durfee Extensometer.

consequently a stress in steel of 30 lbs. per sq. in., and in concrete or wood of 3 lbs. per sq. in. can be observed.

The instrument (see Fig. 1) consists of a bar which is placed on the surface of the material to be tested, and rests at one end on a small pointed leg. The other end carries the measuring device. It is supported on a roller, journaled by pivots in the frame bar, on top of which is mounted a perfectly flat eye-glass. Resting upon this glass is another, but convex, eye-glass (in the instrument built by the designer this was of 160 ins. radius of curvature), which, of course, touches the first at but one point. By looking through the second lens the point of contact, by reason of the interference phenomenon of light known as Newton's rings, may be observed as a small bright spot or target of about ⅛ in. diameter.

In using this extensometer, it is held against the surface of the material to be tested, as shown in Fig. 1. Any stretching or shrinking of this surface will thereupon cause the roller beneath the frame to turn and to tilt the attached glass. Consequently the point of contact of the two glasses will move and become visible as a rapidly shifting target of light. Its motion is many times more rapid than that of the original roller, 500 times in the instrument actually built. As the position of the target may be read to the nearest 1-100 in., the apparatus will detect a displacement in the roller of 1-50,000 in. The position of the target is read on a paper scale pasted on the upper glass.

Examples of measurements made with this instrument are shown in Figs. 2 and 3. The diagram in Fig. 2 shows the elongation during flexure of a reinforced concrete beam, the observation being made on a 16-in. length of its under surface. The load was applied by the testing machine at points 22 ins. from each end support of the beam, which was 88 ins. long, 3 ins. wide, 9 ins. deep, and reinforced with ¼ sq. in. of steel 1 in. above the bottom. The numerous breaks in the curve represent the sudden partial failures and cracking of the beam.

In the above case 87 micrometer observations were made during a total stretch of 17-1,000 ins. The testing machine was run continuously until the target had traveled the length of its scale, when the machine was stopped for an instant while the target was set back to the first part of the scale. Except for six halts of this kind, the micrometer measurements were read off continuously as fast as a man could talk.

Figure 3 shows the compression curve of a short 6 in. × 6 in. concrete pillar, the compression being measured on a length of 16 ins. (for one side of the pillar only). This curve includes 40 observations, and when plotted none of the individual points lies outside of the width of the line as drawn.

This extensometer was designed by Mr. Walter C. Durfee, of the College of Engineering of Harvard University, and is described in the Harvard Engineering Journal, June, 1906, from which the above information was derived. As Mr. Durfee does not intend to patent or to manufacture this instrument, it may be made and used by anyone who so desires.

THE STEEP-GRADE ELECTRIC RAILWAY FROM ALTO TO LA PAZ, BOLIVIA.*

The city of La Paz, the seat of government of the Republic of Bolivia, has a population of 60,000 and is situated upon the Choqueyapu River at the base of the main range of the Andes, with Illimani (21,192 ft.) to the northeast and Illampu (24,812 ft. high) to the northwest. The approach to the city from the coast is by standard gage railways of southern Peru from Mollendo to Puno, the Peruvian port on Lake Titicaca, thence by steamer to Guaqui, the principal Bolivian port, thence by the meter gage railway to the Alto of La Paz, a point on the great tableland, with an elevation of 13,700 ft. The level of Lake Titicaca is 12,540 ft., the general slo[pe] the tableland above La Paz towards the la[ke]

The station of the Alto, the termination [of the] road, lies upon the edge of the great [plateau that] stretches from Vincocaya 300 miles to the [south and ex]tends 600 miles to the south at an averag[e altitude of] 13,000 ft. About 300 ft. beyond the stat[ion the plain] suddenly ends at the edge of the immense [chasm 1,] bottom of which lies the city of La Paz, 1,[000 ft. at the] and 1.25 miles distant in a straight line. [2,000 ft. below]

The problem was how to bring down the [line] steam section of the Guaqui & Alto line i[n the safest] and most economical manner. The quantit[y of freight] to be dealt with was estimated at 1,500 tons [per month;] this was too low; the freight movement [during the first] month has been over 2,000 tons and is increa[sing. Sev]eral surveys had been made of lines from th[e plateau to] the city. None were satisfactory. Usually t[he cost was] excessive. The alternatives were as follow[s: (1) A] steam road with 3% grade; (2) a rack-rail l[ine; (3) an] aerial tramway; (4) an electric line. The l[atter was de]cided upon, with a meter gage, maximum gra[de of 6%,] and curves with a minimum radius of 328 ft.

The location was a difficult one, and in order to reach the obligatory point in the valley above the town it was necessary to run the curves without compensation and in several cases omit tangents between curves. The earthworks are heavy for a meter gage line, running over 18,000 cu. yds. per mile, and several fills are over 40 ft. high. Lumber costing here $90 to $100 per 1,000 ft., trestle work is too expensive. There are two small bridges, one of three spans of 33 ft. each and one of one span, both of 21-in. steel I-beams carried on towers built of 60-lb. rails on masonry bases.

The sub-grade is 12 ft. wide, with 6 ins. of stone ballast under the ties and filled with same to rail level. The ties are of red pine imported from Oregon, 6 ft. 5 ins. × 8 ins. × 6 ins., laid 14 and 16 to the rail length on tangents and curves. The steel rails are Carnegie pattern, 60 lbs. per yd. and 30 ft. long.

The difference in level between the junction with the steam line and the terminus in La Paz is 1,[130] ft., and the length of the line is 6 miles.

The work was carried out entirely with Indian labor, except the technical part and the erection of the machinery and rolling stock. All material, including tools, had to be imported, and in several cases more than a year elapsed between the dispatch of the order and the arrival of the material. The survey was begun in February, 1904, and the line was opened for traffic on Dec. 1, 1905.

The electric system adopted is the overhead trolley, supplied with a direct current at 550 volts by two 275-KW. dynamos, each worked by a 400-HP. gas engine supplied with gas by a Mond gas plant. The altitude of the power station being 12,500 ft., each engine does not develop more than 320-HP. The electric plant was supplied by the General Electric Co. The rolling stock consists of first and second-class and baggage cars, supplied by the Brill Co. Each car will haul one of the freight cars of the steam line, being fitted with two 35-HP. motors. The steam line rolling stock is fitted with Westinghouse air brakes worked from the locomotive on the first (steam) section and from the motor cars on the second (electric) section. These motor cars have Stirling hand brakes, track (slipper) brakes, and can be braked by the motors.

The complete scheme, of which this line is a part, is to continue the electric section over the main range of the Andes, crossing at an elevation of about 14,000 ft. on to Puerto Pando, the head of navigation on the Beni River, an affluent of the Amazon. A power station would then be built to utilize the immense water power to be found on the northern slope of the Andes and sufficient power developed to supply electric current to the following lines: Guaqui to La Paz, Ulloma to La Paz, La Paz to Yungas, altogether about 217 miles.

The total cost of the electric section from Alto to La Paz has been $420,000, or $70,000 per mile. This includes one station and one terminus, power house, land, and all equipment. It is too soon to speak with any confidence of the economic success of the new section, but technically it has been an entire success.

*Abstract of a paper by Mr. J. Pierce-Hope, Constructing Engineer of the railway; reprinted from the annual proceedings of the Michigan Engineering Society for 1906.

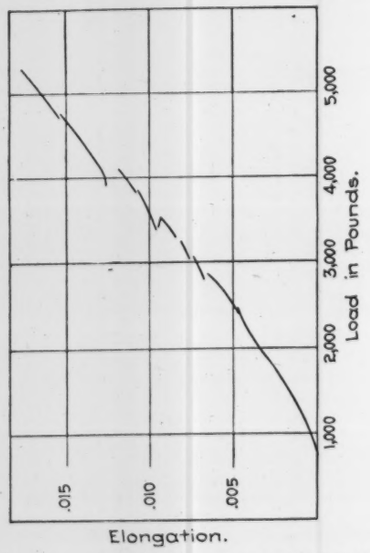

Fig. 2. Stress Diagram of a Concrete Beam, Obtained with a Durfee Extensometer.

(The number of observations plotted is 87, all of which lie within the thickness of the curve.)

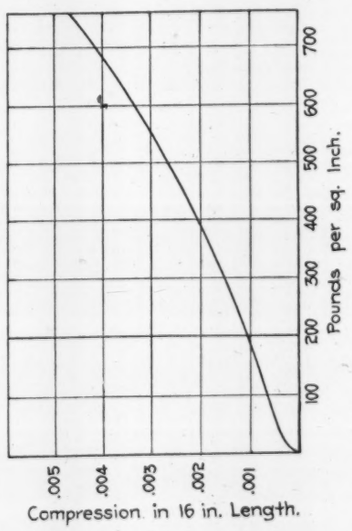

Fig. 3. Compression Curve of a Short Concrete Pillar, Obtained with a Durfee Extensometer.

(The thickness of the curve includes all the 40 observed values.)

BAUXITE LINING FOR CEMENT KILNS has been tried by the St. Louis Portland Cement Co., and a lining of 6-in. bauxite blocks was in continual use for nearly 12 months (8,208 hours), with an average loss by wear of only 2½ ins. This was for a length of 10 ft. in the hot zone of a rotary kiln 6 ft. diameter and 60 ft. long, with pulverized coal for fuel. The bauxite blocks are basic, being high in alumina, and the affinity for the cement mixture and the lining is therefore not strong at the same time they are hard, but with a certain porosity conducive to adhesion of the cement, which forms a coating protecting the lining from the direct attack of the flames. The heat conductivity is low, and it is estimated that a 6-in. lining of bauxite will be equivalent to a 9-in. lining of firebrick, besides having double the life of the latter. These bauxite blocks were made by the Laclede Fire Brick Mfg. Co., of St. Louis, Mo.

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Grave reflections are inevitably aroused by reading that the city of Valparaiso has just gone through San Francisco's experience of earthquake destruction, only four months after the fateful eighteenth of April. It is impossible not to feel an inner conviction that the two earthquakes, though in districts thousands of miles apart, have an immediate connection. The steep ridge of mountains that borders the eastern edge of the Pacific basin continues unbroken from San Francisco to Valparaiso, and the Rockies doubtless were produced by the same forces that raised up the Andes. It is natural to conclude that the causes which disturb one will also affect the other. Geologists promptly announced, after the San Francisco earthquake, that that disturbance was "tectonic," connected with mechanical readjustment of the earth's crust, and they further told that the disturbance and readjustment extended in a narrow belt for hundreds of miles along the coast, parallel to the line of the mountain chains. One wondered at the time why the readjustment was not more generally felt along the western mountain line of the two continents, and how the dozen feet of longitudinal slipping were taken up, at the ends of a crack not over three or four hundred miles long, without leaving uncompensated stresses and the possibility of further trouble. The Valparaiso earthquake, whatever its true cause may have been, comes to the mind as a vague answer to these wonderings. And simultaneously there rises the apprehensive question: Is the remainder of the mountain line not subject to the same structural conditions as are central California and central Chile? Where will the next shear cracks appear?

It seems likely that in the future much attention must be given, in certain districts at least, to what we may call *earthquake construction*. Buildings mainly, but also dams, tunnels, bridges and piers, pipe systems and the like, must be built in such a way that they can resist the vibratory impulses of earthquakes to a reasonable degree. The experience had with thousands of structures in the California earthquake of last April affords the certainty that in the matter of buildings it is not impossible, or even very difficult, to accomplish this. Dams are also not difficult subjects to deal with, if we may judge by the record they made in the region around San Francisco Bay, and it seems probable that bridges may with little trouble be rendered *fairly* resistant; pipe systems and tunnels should prove more stubborn subjects for treatment. With the hope, then, that a large improvement in the resisting powers of earthquake districts may be accomplished without revolutionary change in methods of design and construction, we are confronted with the duty of making thorough study of the subject in order to seek out those features of general arrangement and detail which best satisfy the new requirements. Up to the present such study has hardly been begun anywhere, if we except Japan.

The merger of three gas associations to form the American Gas Institute, now virtually completed after a year or so of conference and planning, is worthy the thoughtful attention of overlapping organizations in other fields. The merger was practically completed on July 10, by the action of duly authorized representatives of the American Gas Light Association, the Western Gas Association and the Ohio Gas Light Association. The first meeting of the Institute will be held at Chicago, Oct. 17 to 19, 1906.

The three old organizations did much good work, and there is reason to believe that after joining forces still more and better work will be done, and at less sacrifice of time and strength on the part of the relatively few upon whom falls the burden of all association work.

From rumors that have been afloat it appears probable that the Central States Water-Works Association is about ready to unite with the American Water-Works Association, probably by dissolution, with the understanding that most of the individual members who have not previously done so will join the American Association. It is too much to hope, and perhaps it is not desirable, that the American and the New England Water-Works Associations will consolidate, but there certainly would be some great advantages in having one instead of two national water-works associations—for it must be understood that the New England Association is by no means restricted to the territory indicated by the name.

Sewage farms, once so much in favor in Great Britain and still serving scores of communities, are now the subject of attack from many quarters. The latest of these that has come to our attention is made the subject of a page "leader" in our London contemporary, "The Surveyor and Municipal and County Engineer," for July 13, 1906. The article opens as follows:

> The latest theory of appendicitis is that it may be caused by an intestinal worm (*trygocephal*), whose eggs can be conveyed by vegetables grown on a sewage farm. This doctrine is supported by the reputations of the savants who have advanced it, and therefore demands respect. Dr. Grassi, in 1886, showed that the ova of *trygocephal*, of the tapeworm, and of the threadworm *oxyuris* may be conveyed by flies.

Using this as a text, our contemporary proceeds to discuss somewhat doubtfully the advisability of applying sewage to cropped land unless the sewage has had preliminary treatment. Among other things it says:

> Without entering upon the relative merits of anaërobic and aërobic action, it may be stated definitely that parasites and their eggs are destroyed by the conditions prevailing either in the septic tank or in the contact bed. In the septic tank the absence of a reasonable supply of oxygen and the poisonous (to small animals) nature of the emanations (trimethylamine, marsh-gas and sulphuretted hydrogen) are sufficient to destroy the eggs, larvæ and imagos of such creatures as intestinal worms. In the contact bed the *amoebae* and other protozoa devour eggs and small larvæ alike, and any adults will find uncongenial surroundings and will die, owing to temperature, lack of prepared nutriment, or to the attacks of other organisms. It is doubtful in the extreme if adult organisms of a parasitic nature could live very long apart from the "host." In both septic tank and contact bed, sedimentation and bacterial contact would still more reduce a parasite's chances of perpetuation of species; and the filtering action of the first and second contact beds, and of the beds receiving septic tank effluent, would nullify that chance altogether. It would be interesting to know the experience of those microscopists who have examined such effluents from biological sewage works as to the nature of organisms found therein, and if anything pathogenic other than a few stray bacilli is of common occurrence. On the Continent, where land treatment is the rule, it is to be expected, if there be anything in the new theory, that cases of disease would occur fairly frequently. In England, however, the percentage of risk is lowered by preliminary treatment as far as large towns are concerned. Chemical precipitation is a sufficient safeguard, if only the question of parasites is considered.

Sewage farming is practiced to such a limited extent in this country that the discussion given above is perhaps chiefly of academic interest here. For the information of our contemporary we would say that, notwithstanding the fact that we do so little in the way of sewage farming, our vital statistics show a large number of deaths from appendicitis. We leave to it the task of reconciling this fact, if it needs reconciliation, with the theory mentioned in the opening quotation given above. As to the effect of septic tanks and contact beds on the larger intestinal parasites, we do not remember having seen any discussion before, but as to bacteria a report of the Royal Commission on Sewage Disposal, made within a year or two, shows that the effluents from so-called bacteria beds (rapid-coarse-grained filters) swarm with bacteria. The experts employed by the commission were emphatic in their opinion that such beds afford little or no protection from pathogenic germs. But after all, these questions seem to be of but secondary importance, since the object of sewage treatment, as a rule, is to produce a non-putrescible effluent, rather than drinking water, and since there is abundant evidence to show that properly operated sewage farms have never been and are unlikely to be a menace to health.

THE STEAM TURBINE IN MARINE ENGINEERING.

One of the most important developments in marine and naval engineering during the present decade, and also one of the most rapid and radical developments, is the application of the steam turbine to vessels of all classes, including large ocean steamers and ships of war. The steam turbine itself, considered as a practicable and commercial machine, is of very recent date, but is already being built extensively for stationary units of large size and high power. This development is due mainly to the skill and energy of Mr. Charles A. Parsons, of England, who in 1884 invented and built the first compound steam turbine. This first machine was of 10 HP., running at 18,000 r. p. m.

In 1894 a syndicate was organized by Mr. Parsons and others to experiment with the application of the steam turbine to marine work. The first turbine steamer to be built was the "Turbinia," 100 ft. long and of 44 tons displacement. At first it had a single turbine and shaft, running at 2,500 revolutions. In 1897 this little vessel attained a speed of 32.75 miles an hour, the highest speed ever reached by a steamer up to that time. This plant was afterwards replaced by a triple turbine arrangement of 2,000 HP., using a high, intermediate and low pressure turbine, and with three propellers on each shaft; the propellers were of small diameter and normal pitch. With this arrangement a speed of 34.5 knots was attained, the turbine developing a total of 2,300 HP. Since then the introduction of the steam turbine for marine work has been rapid, being first used mainly for torpedo-boats, torpedo-boat destroyers, steam yachts and other small craft. It may be noted that in 1905 two of these "destroyers" of the British navy attained a speed of 36 knots, as against 31 knots by similar vessels equipped with reciprocating engines. The first turbine passenger steamer of any size was the "King Edward," built in 1901, for service on the Clyde, and the results were so satisfactory that there is now a large number of turbine steamers in the several fast passenger lines of cross-channel and local service in the waters around the British Isles. At the same time, turbines have been adopted for larger and larger naval vessels.

The first turbine steamer to cross the Atlantic was the yacht "Emerald," of 700 HP., in 1903; and the next was the "Turbinia," built on the Clyde in 1904 for Canadian service on Lake On-

tario. In 1905, the Allan Line had the prestige of putting in service the first regular turbine transatlantic liners, the "Victorian" and "Virginian," running between Montreal and Liverpool. In the same year the Cunard Line put in service the twin-screw "Caronia" and the triple-screw turbine steamer "Carmania," these being sister ships designed for moderate speed. The most notable ships of the present year are three immense turbine steamers: one of these is the largest battleship in the world, the "Dreadnaught," of the British navy; the others are the two largest ships ever built (exceeding the historic "Great Eastern"), being the four-screw, 25-knot steamers "Lusitania" and "Mauritania" of the Cunard Line. There are also some turbine steamers of moderate size on the Pacific and the Indian oceans, including the liner "Maheno," 440 ft. long, running between Vancouver and New Zealand ports. Thus, in little more than a decade, this new type of rotary steam motor has proved itself sufficiently valuable and reliable to replace the reciprocating engine in the largest and most powerful vessels of the naval and merchant marine.

The five turbine steamers for the transatlantic service are described in another column, and of the Canadian steamer "Turbinia," mentioned above, it may be interesting to note that it is a triple-screw steamer of 1,100 tons displacement, 260 ft. long, with a loaded draft of 9 ft. Its propellers are 49 ins. diameter, with a pitch of 44 ins., and the three turbines develop about 3,400 HP. The two boilers (with water) weigh 70 tons; three turbines and shafts, 58 tons; auxiliary machinery, 5 tons. The average speed in crossing the Atlantic was 17.5 knots, and it is stated that in spite of the pitching the engines never raced sufficiently to operate the governors, although these were set to come into action with an increase of only 40 revolutions above the normal speed. In a test on Lake Ontario the steamer made a run of 31½ miles in 1 hour 20 min. (23.7 miles an hour), with a coal consumption of 1.46 lbs. per I. HP. hr., and an evaporation of 8 lbs. of water per pound of coal. The boiler pressure was 160 lbs., reduced to 122 lbs. in the high-pressure and 45 lbs. in the low-pressure turbines, while the vacuum was 27½ ins. The high-pressure turbine was run at 650, and the two low-pressure turbines at 717 r. p. m. This steamer is now in service between Toronto and Hamilton, Ont.

Only a very few small turbine steamers have as yet been built in this country; a passenger steamer with three Parsons turbines is being built for passenger service on Long Island Sound, and a 440-ft. twin-screw vessel with two Curtis turbines is being built for the coasting service of the Morgan Line (New York and New Orleans). The Navy Department has also under contract three steamers of the scout class which are identical as far as the hulls are concerned, but have different types of propelling machinery, as follows: "Birmingham," reciprocating engines; "Salem," Curtis steam turbines; "Chester," Parsons steam turbines. On the completion of these vessels it is expected that very valuable information will be obtained in the comparison of the engines and two types of turbines in vessels of the same size and the same hull construction.

In all these cases of ocean and channel steamers the turbine propelling plant appears to be entirely successful in regard to high speed, coal consumption, absence of vibration (with consequently less discomfort to passengers), absence of racing of the screws (with consequently less strain on the shafts and engines), and general reliability and comfort. In spite of the application of balancing systems to marine reciprocating engines it is impossible to entirely prevent perceptible vibration due to the action of the engines, and this is sometimes exceedingly unpleasant. But with the steam turbine as a rotary engine mounted directly upon the shaft this trouble is practically eliminated. This is the case not only in smooth water, but also in heavy Atlantic seas and the rough, "choppy" seas of the channel. In two different lines of channel steamers, operating both ordinary and turbine vessels on the same routes, the latter have shown a material economy in coal and oil, with higher speeds and a smaller engine room force. The results obtained with some of these vessels were given in our issue of Oct. 26, 1905. The principal advantages of the turbine system for passenger steamers of all classes have been stated by Mr. Parsons as follows: (1) Increased speed for the same boiler power, due to a considerably reduced weight of machinery and increased economy in steam. This advantage increases with higher powers and speeds, but only up to a certain limit, as will be shown later. (2) Reduced boiler power and coal consumption for a given speed. (3) Absence of vibration, giving greater comfort to passengers. (4) Increased cabin accommodation due to smaller machinery space. (5) Less cost of maintenance of machinery, and, (6) smaller engine room staff.

While the steam turbine has been applied to merchant steamers of various classes, these are almost invariably vessels running in a regular service, and the turbine system does not yet seem to be well adapted to the conditions obtaining in that large and important class known as "tramp" steamers, which go wherever a cargo can be obtained and make long runs light or in ballast. It is not improbable that this may come later, giving these steamers the benefits of reduced coal consumption and maintenance expense, with a small engine room staff. Indeed, it was at one time considered that the turbine system could not be economically applied to warships, which require a high power capacity, but which, in cruising and general peace service, are normally run at low power and speed. These conditions do not obtain in the "liners" of the regular merchant service, which run normally under full power. It has been found, however, that the steam turbine can be economically employed in naval service. The British Navy Department in building some 360-ft. cruisers of 3,000 tons displacement had some of the vessels equipped with steam turbines and the others with reciprocating engines. The former had the two side shafts fitted not only with the main and reversing turbines, but also with special turbines for cruising, the main high-pressure turbine on the middle shaft being cut out of service entirely when these cruising turbines were running. By the use of this special arrangement, it was found that the turbine cruisers showed a higher economy than the others, even at low speeds, while at high speeds their coal consumption was 30% less.

No figures are as yet available as to the actual results in coal consumption of ocean turbine steamers, but in very large steamers it is not probable that there is any great saving as compared with steamers having reciprocating engines of the best and most economical design. In the twin-screw "Caronia," of the Cunard Line, the reciprocating engines are said to require only 13.4 lbs. of steam per I. HP., the boilers giving 11.30 lbs. of steam per pound of coal, and the coal consumption being 1.29 lbs. per I. HP. hr. As to the new Cunard 25-knot steamers, "The Engineer," of London, remarks as follows:

> After a certain power has been reached it does not appear that mere size does much to augment thermodynamic efficiency, and we shall probably do the turbines of the "Lusitania" no injustice if we take their consumption at 15 lbs. of steam per HP. per hour.

It is stated that on the two turbine ocean steamers of the Allan Line, with a sea speed of about 17 knots, the coal consumption is practically the same as for triple-expansion engines of the most modern type.

The steam turbine is non-reversible, and in order to reverse the screws and so drive the vessel astern or check its forward motion, supplementary turbines are required, which are so built as to revolve in the opposite direction from the main turbines. The usual arrangement with three screws is to put the high-pressure turbine on the central shaft, and the low-pressure turbines and reversing turbines on the side shafts. With twin screws, of course, both shafts are fitted with the reversing turbines. In the new quadruple-screw steamers for the Cunard Line, the low-pressure and the reversing turbines are attached to the two inner shafts. This somewhat reduces the efficiency in manoeuvring, but is necessary to secure the best and most efficient arrangement for the normal arrangement with the steamer going ahead. The reversing turbines are keyed upon the shafts and normally revolve idly, thus representing a certain additional dead weight. They can be operated independently, so as to assist in steering or manoeuvering the vessel, as in entering port or coming along side the pier.

In one particular, at least, there is considerable doubt and uncertainty as to all new turbine steamers, and that is in the form and size of the screws for the high speed of revolution. In both of the Allan Line steamers, built by different firms, the first screws proved unsatisfactory, and were changed for others of smaller diameter (8 ft.). In at least one of these vessels the original screws had four blades, but we believe that both now have three-bladed screws. These important changes were necessary in spite of long and careful investigation and extensive tank experiments. In fact, the design of screw propellers for either reciprocating engines or turbines (but especially for the latter) is still a matter which is largely vague and indefinite, and it is almost impossible to predict with any certainty what results will follow the application of a given form of screw to a given vessel. Mr. Parsons made careful experiments in regard to high-speed screws, and came to the conclusion that in all screws there will be a limiting speed of blade, depending upon the slip ratio and the curvature of the back (or the thickness of the blade); at speeds beyond this limit there will be a great loss of power. On this basis he estimated that if the speed of ships were to be increased, it would be desirable to adopt larger pitch ratios than were then usual (1897). The propellers must not be run at too high a speed, being kept at such a limit that they may be of coarse pitch and with sufficient area to deliver an adequate thrust to maintain the required speed of a large steamer in heavy seas. Screws for high speed of revolution must be of small diameter and fine pitch, but on the other hand such screws are inefficient in propelling power and not adapted to rough service. For this reason, the builders of the "Carmania" adopted turbines of great size (14 ft. diameter and 36 ft. long) in order to secure a comparatively low speed of revolution. As to the immense new turbine steamers of the Cunard Line (each of which will have four screws with three blades) "The Engineer" makes the following remarks:

> The "Lusitania" is fitted with four separate propellers, and each of these will have to absorb, say, 16,500 HP. At 30 miles an hour, or 2,640 ft. per min., a gross total thrust of about 360 tons would represent 65,000 HP. But it is unfortunately only too well known that of the total power imparted to any screw propeller, not much more than half (sometimes, indeed, not so much) ever reappears at the thrust block. What becomes of the difference? That is the problem that vexes the souls of naval architects and engineers alike. Half a century of investigation, mathematics, experiment and discussion have left the world no wiser; and there is just as considerable fluidity of opinion now as at any other time as to how a propeller acts and how 50% of the power imparted to it is wasted. It is possible that the propellers of the "Lusitania" may be greater than 50%; whether they will or not is a most interesting problem which can only be solved by Atlantic experience. Taking for granted that it will be only 50%, then the thrust will amount to 180 tons, or 45 tons on each shaft.

The steam turbine runs at relatively very much higher speed than a reciprocating engine of the same power, but the actual speed varies inversely with the size of the steamer and the turbine. In yachts and torpedo-boats the speed may be as high as 2,500 r. p. m., while in the 260-ft. "Turbinia," on Lake Ontario, it ranges from 500 to 700 revolutions. In the Allan Line steamers, 540 ft. long, it is about 260 to 300 revolutions. In the Cunard Line steamer "Carmania," 678 ft. long, the speed is 185 revolutions, as compared with 86 for the reciprocating engines in the sister ship "Caronia." In the immense and high-powered new Cunard steamers (nearly 800 ft. long), the speed of the turbines and screws will be about 150 r. p. m. In comparison with the above

figures we have the following range of speed for reciprocating marine engines: (1) in torpedo-boats and destroyers, 400 r. p. m.; (2) in the U. S. cruiser "Tacoma," 175 revolutions; (3) in the U. S. battleship "New Jersey," 126 revolutions, and in the U. S. battleship "Louisiana," 103 revolutions; at 16 knots to 124 at 18 knots; (4) in the high-speed transatlantic steamers "Kaiser Wilhelm II." and "La Provence," 80 and 87 revolutions, respectively; (5) in the large but moderate-speed transatlantic steamers "Arabic" and "Baltic," 78 revolutions.

With the higher speed of revolution of the turbines, however, a smaller diameter of shaft is permissible, and we find the Allan Line turbine steamers using 12-in. shafts, as compared with 20 to 26-in. shafts in fast high-powered vessels driven by reciprocating engines. The propeller shafts are 19 ins. diameter in the "St. Louis," 24 ins. in the "Campania" and 25 ins. in the "Kaiser Wilhelm II." In the two sister ships, "Caronia" and "Carmania," the former has 23½-in. propeller shafts for its twin-screw quadruple-expansion engines, while the latter has 14-in. shafts for its triple-screw turbines. The elimination of crank shafts, with their reversal of strains and possibilities of fracture, is a very important point in favor of the turbine system.

As already noted, the speed of the turbine decreases with the increase in power, and this means that a greater size is necessary, so that the diameter of the turbine increases in greater ratio than the power developed. As a consequence of this, the economy in weight as compared with reciprocating engines diminishes as the size and power of the turbine steamers are increased. In four similar boats in the Irish Channel service, the reduction in weight of machinery in the two turbine boats was 115 tons, or 15% of the total weight of engines, boilers, etc. In the sister ships "Caronia" and "Carmania," already mentioned, the triple-turbine equipment of the latter represented a saving of 5% over the twin reciprocating-engine equipment of the former. In designing the immense new steamers for the Cunard Line it was estimated that the saving in weight would be only about 300 tons, as compared with reciprocating engines for the same power; this saving is so small in proportion to the total weight that it was considered negligible.

The floor space occupied is about the same for both turbines and reciprocating engines (including the condensers and auxiliaries), but with the turbine there is a material reduction in the cubic space occupied, owing to the low height as compared with vertical marine reciprocating engines. This is important in passenger vessels, as it gives greater and more unbroken deck and cabin space, with accommodation for a greater number of passengers. In fact, in the two Allan Line turbine steamers it is estimated that the space saved by the adoption of steam turbines gave accommodation for 60 additional passengers. In warships the low turbine plant has advantages in that it not only interferes less with the decks, but also requires less special means of protection than the high reciprocating engines. In a review of marine engineering read before the British Institution of Mechanical Engineers in July, 1901, Mr. James McKechnie compared the equipment of steamers with reciprocating engines and steam turbines of 7,000 I. HP. as follows:

	Reciprocating Engines.	Steam Turbines.
Weight	270 tons.	190 tons.
Floor space	911 sq. ft.	911 sq. ft.
Cubic space	14,430 cu. ft.	10,500 cu. ft.

It must be remembered that the marine steam turbine has not yet, in its short but eventful life, had the same opportunities for development as the reciprocating engine. The number of turbine steamers is small and the length of their service is limited, but with more numerous examples and with longer experience in the design and working of steam turbines many important developments may confidently be expected. In the first place, as turbines become more generally used, their cost will naturally be less. Then a reduction in weight may be looked for, especially if screw propellers can be designed that will be of high efficiency at greater speeds, since the same power can then be developed by a smaller turbine running at greater speed. Reductions in coal consumption may also be expected. Still another important line of development will probably be in the simplification of reversing arrangements, and especially in the adaptation of special arrangements to permit of vessels steaming economically at either high or low speeds. This last, combined with low cost, will enable the owners of the vast fleet of tramp steamers and cargo boats to benefit from the economy in coal consumption and other advantages of steam turbines as compared with reciprocating engines for the same power and speed of ship. Certainly the steam turbine has had a remarkable development in marine engineering, and it seems probable that it marks the beginning of a new era in this branch of engineering.

LETTERS TO THE EDITOR.

Long Railway Tangents and Curves.

Sir: In your "Notes and Queries" E. P. L., of Buffalo, N. Y., inquires for information as to the length of the longest tangent and the longest curve in the United States, and I note that you cite a case in Argentina, thus making the question an international one.

In 1903 I built a line for the Canadian Pacific Railway southeast from Regina, in the Northwest Territory, which had a tangent, after leaving the main line at Regina, 93 miles long, a little more or less, I am not sure which now.

As to the question of length of curve, there is a 10° curve on the Great Northern Railway at Martin Creek Tunnel, Cascade Mountains, that has over 270° central angle. But this is not nearly so long as the curve a friend of mine put in on rather a small angle, when instructed by the chief engineer to use a flat curve.

Yours truly, J. G. Sullivan,
Assistant Chief Engineer, Isthmian Canal Commission.
Culebra, Canal Zone, Aug. 1, 1906.

Coal Tar Paints.

Sir: The interesting and valuable letter from Mr. Alfred E. Forstall, lately Secretary of the American Gas Light Association, in your issue of Aug. 16, 1906, on the subject of painting gas holders with prepared coal tar should go a long way towards establishing confidence and encouraging trial of this remarkably economical protective coating. That it will incidentally restore and maintain confidence in real lead paint is also of value.

The tar paint as prepared by Mr. Forstall by boiling, and applied hot on a heated surface, requires time and labor which a great deal of work will not warrant, and which many would not take the trouble to do.

It will occur to most of your readers that the Portland cement used in my proposed mixture not only neutralizes the acid property of the coal tar, but removes the water as well, and hence is a substitute for both lime and boiling.

In Mr. Forstall's experience that coal tar paint will protect a coating of red lead for 20 years, the engineer has valuable information for emergencies, and which makes him largely independent of the paint manufacturer. No one who has thoroughly investigated the matter, questions the value of red lead paint as an original protective coating: it is expensive when correctly made and applied, but if it can be preserved for 20 years with such a cheap covering as coal tar paint the final economy will be great.

Very truly yours,
A. C. Cunningham,
Civil Engineer, U. S. N., Bureau Yards and Docks,
Washington, D. C., Aug. 16, 1906.

Starting a Card Index System for Engineers and Contractors.

Sir: By way of starting a card index system, such as was described in your issue of Aug. 2, I suggest to the engineer or contractor that he equip himself as follows:

Get a small, "loose-leaf" pocket-book with a stout cover and quadrille-ruled leaves 3 × 5 ins. Into this book put all memoranda.

Fit on the right-hand side of the office desk, under the pigeon holes, a drawer holding 3 × 5-in. guide cards, record cards and leaves from the pocket-book. This drawer should have no arrangement for holding the cards in place other than a "following block." Memoranda, business cards, etc., may then be slipped in behind the guide cards without being perforated or cut. A set of alphabet guide cards holds names and addresses. For the blank guide cards get "three cut" cards, and letter one set with names of contracts, etc. Take the "Classified Advertisers' Directory" from Engineering News and have the office boy cut out the headings and paste them on the tabs of another set of guide cards. The lists of advertisers also may be pasted on record cards and placed in this index. This gives a good start to the card drawer. From time to time used memoranda leaves are taken from the pocket-book and placed behind their proper index cards in the drawer; blank leaves are substituted in the book. The "loose-leaf" books, card drawers, and cards, are carried in stock by a number of stationers, 3 × 5 ins. being a standard size.

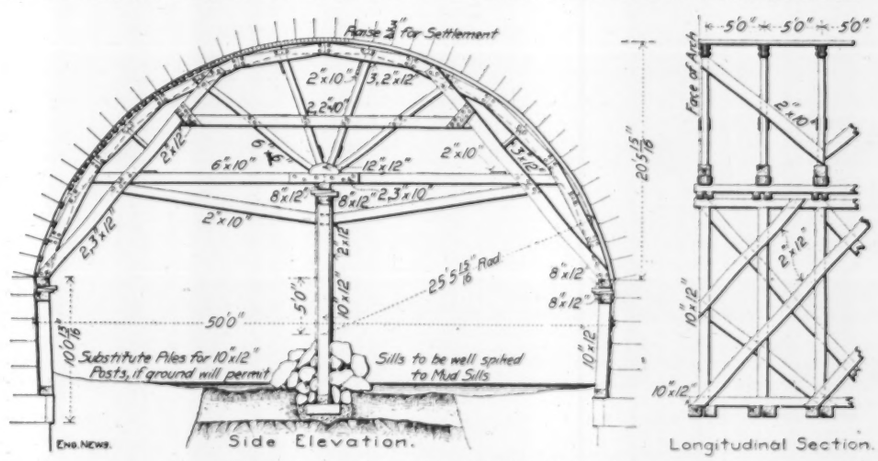
If enough engineers and contractors adopt this system perhaps Engineering News will supply its "Advertisers' Directory" in card index form and advertisers will send out their literature on 3 × 5-in. cards. It is not necessary to point out the great convenience that would result.

A. C. Gildersleeve,
Assoc. M. Am. Soc. C. E.
New York City, Aug. 16, 1906.

A Special Form of Arch Centering.

Sir: I enclose herewith a plan for centering for a segmental arch of 50-ft. span with voussoirs 30 ins. deep, which I trust will interest some of the readers of the Engineering News, as very little practical information is given in the text-books on this subject, which could be applied to any particular case.

Owing to the stream becoming rather wild at times, it was desirable to place as little obstruction as possible in the bed of the stream. A truss was considered with supports at each abutment only, but as the cost was excessive, and there were doubts as to its rigidity [the angle of main supports being so flat, due to rise of arch], and not caring to use iron rods, it was discarded in favor of the plan herewith. The centering shown is well bolted, so that it can be moved, the section used being one-third of the whole length of arch.



CENTERING FOR 50-FT. MASONRY ARCH.

Possibly some of the readers have had occasion to solve a similar problem lately for segmental arches of 50-ft. span or over, in which case it would be interesting to learn something of the design and what the results were, as some of the stresses in centering for arches are so indefinite it is difficult to proportion the whole economically.

Yours truly,
J. H. Milburn.
Baltimore, Md., Aug. 7, 1906.

Rolled Maps or Separate Sheets.

Sir: In reference to Mr. F. Lavis' letter in your issue of April 26, 1906, as to the above, the writer does not agree with your correspondent in his conviction that "the quality of railway location is bound to suffer by the use of separate sheets," providing that the sheets are used in the proper manner; i. e., only to fix the final location on the adopted preliminary in country which requires that contours be taken.

The veiled sneer at "theory" is somewhat out of place in this connection as no work has been published on the subject except by writers of long practical experience. "Wellington" is a strong advocate of the separate sheet method not as theory but as the result of his experience in the class of country in which such method was advantageous. Wellington was not a "genious" of the cowboy class, but certainly was a genius in the respect of having "the capacity for taking infinite pains."

It would be folly to try to project the general route on large scale plans on separate sheets. The general location would be fixed on small scale maps—at least long enough to cover from one fixed point to another—say 10 or 20 miles. (Detail topography such as contours would not ordinarily be taken on "various projected lines"). This map would generally remain in camp as a record and copies be taken into the field for study on the ground for reconnaissance work. All your correspondent's objections should disappear if this view be taken.

It has always been the writer's practice to use: (1) A small scale map of the whole country or state showing the whole route; say 4 miles or 8 miles to 1 inch. (2) Larger scale locality plans showing various alternative preliminaries, say 4 ins. to the mile. (3) Large scale contour sheet plans to be used in the field, as described by Wellington, on the adopted route, the preliminary of which should be fairly close to the final location, say 20 or 40 ins. to the mile.

Theory or reading of books will not teach a man how to run sensible preliminary lines. For this he must have a certain gift, somewhat rare, called "common sense." By the method shown in my pamphlet on "Railway Location in Australia" (pp. 27-30), published by Engineering News, the minimum necessary amount of topography is taken and compass work saved by using the field drawing board as a plane table to get direction of spurs and gullies; also a much clearer mental impression is obtained of construction difficulties, what drainage to provide for, etc.

The writer has never found any annoyance from having to arrange flat sheets, but has often been annoyed when trying to flatten out other people's rolled plans. It is hard to imagine that topography could be taken in a less expensive way than in the field, because the engineer then takes only what is necessary for final location and not 200 ft. or 300 ft. indiscriminately to right and left of preliminary. The gradients to work to should be settled upon before starting detail topography, and in rough country the limits of possible curvature should be sketched on sheets.

Of course the field sheets become soiled somewhat, but if a man is anxious to send in "pretty" plans he can have them copied onto new sheets by transfer paper or make a tracing roll for record.

In conclusion, however, I may concede that perhaps poorer results would be obtained by using large-scale flat sheets *only*, without a locality plan than by using a large-scale roll, but either method of using large-scale plans only is bad practice. Yours very truly,

D. M. Fraser.
Locating Engineer.

Seremban, Federated Malay States, June 26, 1906.

Screw Spikes for Railway Track.

Sir: I have read in your issue of June 21 the very interesting article on "Screw-Spikes and Wooden Tie-Plates for Railway Track," and as I recently had the opportunity of studying the track problem in the United States, I would feel much obliged if you would allow me to express an opinion on the subject.

Owing to the intensity of the traffic and to the enormous increase of weight of both the motive power and the rolling stock, during recent years, the track material has been considerably reinforced. The joints are stronger, the rails heavier than they used to be, and the number of ties per mile is still greater than on European lines. But the fastenings of the rails have not been improved, and American engineers are still using the old system of the spike, which does not seem to answer actual requirements. Moreover, it is a well-known fact that the spike is very harmful to the ties.

In my opinion, an ideal system of fastening for American roads should be (1) strong and resisting; (2) easy to fix and to remove; (3) cheap. The chief object of a fastening must be to ensure a constant pressure of the rail against the tie so as to avoid the hammering action of the rail. A perfect fastening must also be able to bear the bending of the rail under the influence of the passing trains. In order to protect the ties against the wearing action of the rails, railways in America are making use of tie-plates, but I think these are not giving the expected results. A practical fastening must be easy to fix properly by any workman, also it must be easy to remove without fear of damaging the tie. Finally, a fastening must be cheap. When speaking of the price of a fastening, I do not consider only its cost price, but also the cost of applying and the cost of maintenance.

I will not examine here the different systems of fastenings employed but shall consider only the screw-spike, which has been used for a long time by most European railways and which has been introduced lately in America. The screw-spike is no doubt a better fastener than the spike, a fact which has been acknowledged by the International Railway Congress at Washington in May, 1905. That Congress, in considering the problem of rail fastenings, adopted a resolution in which it was said that the spike was not a sufficient fastener for American railways under the present conditions and recommended the use of the screw-spike. However, this is not yet a perfect fastening. There are cases where it has been necessary to consolidate the attachment procured by the screw-spike, besides it is rather hard and difficult to fix, especially in hard wood ties, and requires, therefore, experienced and skilful workmen. Finally, it is not easy to remove on account of the damage caused by that operation to the wood fibers.

All these conditions have led me to the invention of my helical linings for screw-spikes, a description of which was given in your issue of June 21. The chief object of these linings is (1) to consolidate the fastening of the screw-spike; (2) to greatly facilitate the fixing of same and enable any workman to do that operation properly; (3) to permit the use of soft woods for railway ties; (4) to repair damaged fastenings at very little cost; (5) to reduce the maintenance expenses; (6) to save ties. As to the cost of these linings, I compare herewith the cost of equipping a tie with the present system and with my system:

Ordinary spikes:	Cts.	Thiollier system:	Cts.
2 tie plates	25	4 screw spikes	6
4 spikes	5	4 linings	8
Labor	2	4 washers	2
		Labor	2
Total	32	Total	18

These figures, based in both cases on the lowest possible prices, show that the present system is actually much dearer than my system, when building new track with tie-plates. When the spike is used without tie-plate, my system necessitates about 10 cts. per tie extra initial cost or about $330 per mile with 3,200 ties per mile. This extra cost is saved in 12 or 18 months by the economy in the cost of maintenance of track.

Experience, in fact, has proved that the use of my system of screw-spike with lining does away with all cost of repair to the attachment. On certain roads in France equipped with my linings it has been possible to reduce the track gang from five to three men, which means an economy of about $62 to $80 per mile.

These linings are now largely used on a great number of the leadng railway companies in Europe and the results they have given during the last five years are most satisfactory. They have already been tried by different railway companies in America: the Boston & Maine Ry., the Southern Ry., the New York Central & Hudson River Ry., the Canadian Pacific Ry., the New York Subway, the Pennsylvania Lines West of Pittsburg, etc.

Yours very truly,

J. Thiollier, Engineer.

92 Boulevard Haussmann, Paris, France, July 26, 1906.

Death Certification, Cremation, and Premature Burial.

Sir: Referring to the interesting note on a crematorium in the city of Washington, D. C., in your valuable journal for July 12, 1906, may I venture to remark that amongst the reforms advocated by the late Sir Henry Thompson, F. R. C. S., during his long and strenuous life in the service of humanity, was the highly important one of death certification and registration? At a special meeting of the Metropolitan Counties Branch of the British Medical Association, May 22, 1896, this distinguished surgeon showed from the returns of the Registrar-General for 1892 that in England and Wales alone there were no less than 15,000 cases of death in which no inquiry was made as to the cause of decease, and no certificate of any kind obtained; also that 25,000 additional deaths "were so inadequately certified as to be unclassifiable"—making together a class of 7½% in which no evidence as to the cause of death existed. It would appear from the second edition of "Premature Burial and How it may be Prevented,"* that although this dangerous condition of affairs has improved somewhat in succeeding years, yet in the five years 1897-1901 no fewer than 53,532 bodies were interred in England and Wales without a death certificate. Sir Henry Thompson recommended cremation as a means for preventing premature burial, because of the dual medical examination of the body required by the regulations of the cremation societies. This, although to a great extent a preventive, cannot be r[illegible]ded as an absolute safeguard, seeing that cases a[illegible]recorded where several doctors have been deceived, [illegible]d pro-nounced dead a patient who has afterwards r[illegible]vered.

In the fourth (and last) edition of his va[illegible]e work on "Cremation," Sir Henry Thompson admits "there is but one really trustworthy proof that dea[illegible]has oc-curred in any given instance, viz., the pre[illegible]e of a manifest sign of commencing decomposition[illegible]nd he adds that "it should always be verified be[illegible]a cer-tificate of death is signed." All the leadi[illegible]medical journals in England now agree that under t[illegible]present lax system of death certification there is [illegible]ger of burial alive, and that reform is needed. [illegible]erefore, whether premature burial be frequent or rare [illegible]d, from the very nature of the case, it cannot be pre[illegible]either way, though, judging by the narrow escapes, t[illegible]danger cannot be infinitesimal) all will agree that [illegible]people should be effectually safeguarded against a[illegible]possi-bility of the occurrence of these terrible tragedi[illegible]. This could be done by Parliament enacting the [illegible]visions contained in the carefully-prepared draft bill of the London Association for the Prevention of [illegible]mature Burial, and should not longer be delayed.

If any of your readers are interested in the [illegible]vention of burial alive, I should be pleased to send [illegible]erature on the subject on receiving the cost of postage.

I am, sir,

Your obedient servant,

Jas. R. Williamson.

100, Chedington Road, Upper Edmonton, London, N., England, July 31, 1906.

[Whatever one's opinion may be regarding the subjects of premature burial and cremation, and whatever may be the deficiencies in the registration of deaths in England, there is no question but that serious deficiencies in this respect exist in a large number of our American states and cities. Complete vital statistics would not only go far towards eliminating the chances of premature burial and other evils attending improper death returns, but they would also aid greatly in the various classes of health protective work carried on, or which should be carried on, by local authorities.

We cannot refrain from saying that there are other and more vital reforms, in our opinion, demanding attention than those that are engaging the attention of anti-vivisectionists and associations for the prevention of premature burial. The extent to which some of these "reformers" go is illustrated by the fact that the author of one of the pamphlets on premature burial, sent by our correspondent, has also written on the subject of "Color in Mourning: A Plea for a Great Reform." A further illustration, and one bearing more particularly upon the subject immediately in hand, is afforded by the following graphical description of a device intended to protect people against being buried alive:

Count Karnicé Karnicki, a Russian philanthropist, whose attention was drawn to the danger of premature burial by having himself assisted at the rescue of a young lady, who was discovered to be alive just as the first clods of earth were cast upon her coffin, has invented a most ingenious contrivance for the prevention of these tragedies. It consists of an hermetically closed iron box, which is placed on the top of the grave, and connected with the coffin below by a hollow removable tube. Inside the tube is a spring which is at one end connected with the iron box, and at the other end, inside the coffin, is a glass ball fixed so that it just touches the chest of the buried person. The slightest movement of the body, as in respiration, suffices to cause the lid of the iron box to spring open, and, at the same moment, a flag to shoot out perpendicularly about four feet above the ground. At the time of the exhibition of the flag, a loud alarm bell is rung, and an electric lamp lighted. These signals are intended to attract attention by night or in the day. By the opening of the box lid the tube admits air and light into the coffin, and also serves as a speaking tube. As the box is in the first instance hermetically sealed it permits no foul air to escape, nor can it be opened from the outside, but only by pressure on the ball within the coffin. This Karnicé invention is steadily growing in public estimation in France, and I am informed that thousands of Frenchmen have ordered it to be adopted in case of their supposed death.

At the risk of seeming to jest on so grave a subject, we would ask, would it not be simpler to provide a telephone in each coffin?

Finally, those who wish to make it absolutely certain that they will not be buried alive should put an iron-clad provision in their will to the effect that they be cremated.—Ed.]

*Edited by Walter R. Hadwen, M.D., etc. (the Amsterdam Publishing Co., 156 Fifth Av., New York, published the first edition of this valuable treatise, by William Teble, F. R. G. S., and Col. E. P. Vollum, M.D., in 1897).

Criticism of Details of the "Universal Dictionary of Mechanical Drawing."

Sir: By what authority does the author of the articles on the Universal Dictionary of Mechanical Drawing," which have been appearing in your journal, change the time-honored custom of expressing feet and inches by making the marks slope downward to the right instead of to the left? Will it be necessary for the older draftsmen to learn their lesson over again or is your correspondent just a little slovenly in this detail?

When writing a fractional part of an inch, why is it necessary that the inch mark should precede the fraction when expressed decimally, and follow it when expressed otherwise? If ".25 is proper, why not "¼"?

Yours truly, C. F. L.

Chicago, July 7, 1906.

Sir: I desire to enter a vigorous protest against the size of standard sheet proposed by Mr. George H. Follows, in his article on "A Universal Dictionary of Mechanical Drawing," in your issue of July 19, 1906.

I think the size chosen, viz.: 8½ × 12½ ins., is ill-chosen. In my opinion 8½ × 10½ ins. would be a better size, for the reason that these are the general dimensions of a letter sheet, as well as those of a multitude of blank forms. This is also one-fourth the size of the well-known paper, 17 × 21 ins., with which all printers are familiar.

In daily correspondence on engineering subjects it is of very frequent occurrence to accompany the same with blue prints of drawings, sketches, tables and other information, and where the "Standard Sheets" are of the dimensions stated, 8½ × 10½ ins., they are thus of the same size as the letters, being very convenient for fastening together, folding, filing, etc. A large number of concerns, corporations, municipalities, etc., are now using this size for their contracts and specifications, which is another argument for its adoption. Lawyers and attorneys also are using this size instead of the time-honored legal cap, binding the loose sheets with stiff cloth-covered covers, making them extremely handy and convenient for use.

Do not let us perpetuate some illogical size just because it happens to be the dimensions of somebody's cross section paper. The strongest argument in favor of sheets of 8½ × 10½ ins. is that letter sheets are always at hand, upon which sketches, tables, drawings, etc., can be made. Oftentimes the size recommended by Mr. Follows is not at hand. It is the writer's hope that for the reasons mentioned the engineering profession will adopt the size of standard sheets mentioned here, viz.: 8½ × 10½ ins. Yours truly, Emile Low.

M. Am. Soc. C. E.

Rome, N. Y., July 21, 1906.

[Mr. Follows, the author of the "Dictionary," replies to the foregoing letters as follows:—Ed.]

Sir: The author maintains that the reversing of the foot and inch marks lends additional character to the complete dimension, and that on this ground alone the change from the "time-honored" mark is distinctly worth while. With regard to the special position of the inch mark immediately above the decimal point in a decimal fraction, there is a *natural* difference between a decimal and a regular fraction which the special position of the inch mark is intended to accentuate. (On both counts I would refer C. F. L. to Part III. of the Dictionary, where reasons were given.) Surely there is nothing difficult for the older draftsman in such small changes as these. But it will be necessary, as C. F. L. suggests, for some draftsmen to change their ideas about what a drawing should be if we are ever to have uniformity where we now have variety. When there is *lack* of uniformity it is not possible to obtain uniformity without introducing changes *somewhere*.

Personally I do not like the term "time-honored." It always seems to me to smack too much of an opposition to progress. Many years' association with drafting rooms in this country and in England has taught me that what is time-honored in one room is abhorred in another. I once had the pleasure (?) of straightening out a drafting room where it had been the custom to cut the tracing to suit the contents. There were scarcely two drawings of the same size on file, and there was variation all the way from 10 ins. × 8 ft. to 6 ins. square. Here was time-honored custom with a vengeance; and even then there was opposition to change.

But I would remind C. F. L. that the "Dictionary" is intended not only for the benefit of such draftsmen and drafting rooms as feel their shortcomings, but also as a help to teachers and students of mechanical drawing in all our schools and colleges. It is not expected that the world of draftsmen will jump as one man into the use of the same system—still less that that system will be the one that I have outlined—but it is hoped that in time through the use of a uniform method of teaching mechanical drawing as a *language* rather than as a *craft*, the next generation of draftsmen will realize the importance of uniformity.

I am sorry that in the chapter devoted to Standard Data I did not explain more fully just how it came about that the size of standard sheet selected was 8½ × 12½ ins., but I did not think at the time that it would be of interest to the majority. I see now that the explanation should have been made.

The 8½ × 12½-in. sheet is simply letter size (8½ × 11 ins.) plus a binding strip 1½ ins. wide. I think that this letter size is in quite as general use commercially as any other—the 8½ × 10½-in. mentioned by Mr. Low, for instance. At the time I investigated the matter I found that the 8 × 10½ in. size was used by many firms (this, by the way, is the size actually used by Mr. Low in his letter to you) but I also found that letter files in general are made to take the 8½ × 11, and this slightly larger size was finally selected as the base upon which to build up the complete data sheet. When it is desirable to mail or to file a standard sheet with correspondence, etc., it is only necessary to trim off the 1½-in. binding strip. Any attempt to use the size suggested by Mr. Low and to allow enough for binding—not less certainly than 1½ ins.—would result in a practically square space for data, a shape that is surely not as convenient as the 7½ × 10-in. rectangle of the proposed sheet.

I shall still hope that the 8½ × 12½-in. size (that is 8½ × 11 ins., plus a 1½-in. binding strip) will be adopted as the standard sheet for general use. It is not intended that these sheets of data shall be the result of hurriedly jotting down information on any sheet of paper that happens to be handy, but rather that they shall be compiled with the utmost care. The 8½ × 12½-in. size was not the result of snap judgment, but was a final decision after most careful consideration.

Mr. Low's arguments are perfectly sound, but I think he will see that in the main his objections have really been met, for I trust that he will agree that the addition of the binding strip is entirely unobjectionable.

Sincerely, Geo. H. Follows.

Canada, Aug. 4, 1906.

The Design of Reinforced Concrete Beams and the Location of Maximum Moment in a Footing.

Sir: The writer has followed with much interest the development of a theory of reinforced concrete design as presented by Mr. Edward Godfrey, and the various comments and criticisms thereon by other engineers. That this is the writer's first participation in the discussion is due to the fact that he disagrees so entirely with Mr. Godfrey's fundamental assumptions that there is no possibility of carrying on a reasonable controversy. As stated in the columns of this paper, and elsewhere, the writer believes that reinforced concrete should be designed for the actual loads to be carried, the factor of safety being obtained by assigning allowable working stresses to the concrete and steel respectively. Where the distance of the neutral axis from the compression surface of a beam or slab is introduced in a formula, the value used, in the writer's opinion, should be that which exists under the working load, when the unit stresses in concrete and steel do not exceed their allowable limits. All authorities seem to agree that, even for the same beam or slab, the neutral axis is in an entirely different position under the breaking load. Without going into the question of formulas at all, there would seem to be no reason why reinforced concrete should not be subjected to the same rules as those which govern designing in other materials. These require the stresses under actual working load to be determinate, and that they shall not exceed the allowable values prescribed for each kind of material. No design that has not been made on this basis can comply with building laws, architects' specifications, and the like, which almost invariably express their requirements in the form of allowable working stresses. It should be apparent that no one formula, involving such variable quantities as the coefficient of elasticity for concrete in compression, and the distance of neutral axis from compression surface, can or should be used for both ultimate and working loads. Let us say, for example, that a beam has been designed by such a formula to fail at four times the working load, and that the maximum compression in concrete at the breaking load is 2,000 lbs. per sq. in. Does anyone suppose that under the working load the maximum compression in the concrete is necessarily one-fourth of 2,000, or 500 lbs. per sq. in.? It may be more or less, according to circumstances, and yet how few adherents of this method re-compute their designs to ascertain the actual maximum working stresses, and to make sure they do not exceed the law or the specifications. Many would not know how to re-compute them, since their favorite formula would have to be altered by the substitution of a new, and higher, elastic coefficient for concrete, and a new, and greater, distance of the neutral axis from the compression surface.

In regard to the percentage of steel to be used, the writer has always maintained that this is a question not only of structural efficiency, but also of economy of cost and architectural restrictions and requirements. We know that in every member subjected to pure transverse bending, the total compressive stress on one side of the neutral axis must equal the total tensile stress on the other side. (Remarkable as it may seem, the writer has heard this well-known fact denied by men in very responsible positions.) There must, therefore, be a certain ratio of steel area in tension to concrete area in compression (neglecting the concrete in tension) which under working loads will give the maximum allowable intensities of stress in each material. This is the structurally economic ratio. If a greater percentage of steel be used, the maximum allowable intensity of compressive stress in the concrete becomes the factor which fixes the resisting moment, and hence the working load. Under this same load, the intensity of tensile stress in the steel will not attain its allowable maximum working value, and the design will be structurally uneconomic. But for easily conceivable reasons the price of concrete may be very high, and that of steel very low, or again, architectural peculiarities may have limited the size of shape of the beam or slab. Under such conditions, the higher percentage of steel may give the greatest economy of cost, and the man who clings to a hard and fast percentage throughout his designing will be at a serious disadvantage.

The writer believes that concrete engineers will be almost unanimous in opposing Mr. Godfrey's statement that the slab, for a certain width on each side of the beam at any rate, should not be considered as part of the compression flange of the beam, if the concrete is deposited simultaneously and shearing stresses provided for in the design. The analogy, submitted by Mr. Godfrey in your issue of July 12, of a buckle plate in a steel floor does not seem to fit the case. If we may consider the table of a steel T-beam, whose width is generally more than ten times the thickness of the stem, as part of the beam, it would not seem unreasonable to consider a width of slab equal to ten times the width of the concrete beam, as an integral part of such a beam.

From the foregoing remarks, it should be evident that the writer must forbear discussing Mr. Godfrey's mathematical deductions, since there is so great a difference of opinion at the very start. One point will be mentioned in regard to footing design. It is the writer's belief that where a cap stone or column base is superimposed on a footing slab, the maximum bending moment in the slab occurs at the center. To compute the slab as a cantilever whose length equals the projection beyond the cap stone, requires that the cap stone itself should be strong enough to take at its extreme edge the entire upward pressure on the projection. As such is seldom the case, the writer believes in using the old reliable formula:

$$M = \frac{P}{8}(l - a)$$

for the bending moment at the center of the footing, P being the column load, l the length of footing and a the length of cap stone or column base. The reinforcing bars are arranged exactly as a grillage of iron beams would be, the strips running perpendicular to each other. In fact, a reinforced footing may be economically designed in practically the same manner as an I-beam grillage, the only difference being that the successive tiers are all in the same plane instead of being superimposed one above the other.

Before closing this letter, the writer wishes to acknowledge the fact that it does not refute Mr. Godfrey's theories. As previously stated, it is impossible to debate the matter from two such entirely different points of view, and like the closing addresses of two opposing lawyers before a jury, these letters mean but little until the verdict is rendered by the readers of Engineering News. Respectfully yours,

John Hawkesworth.

100 W. 80th St., New York, July 27, 1906.

[Mr. Godfrey's reply to the above comments is given below, together with a reply to criticisms by Mr. M. Morssen. The letter of Mr. Morssen was printed in our issue of Aug. 2, but the reply which should have followed it was omitted, through an oversight.—Ed.]

Sir: I beg to thank you for the opportunity to reply to the letters of Mr. Michael Morssen and Mr. John Hawkesworth.

Mr. Morssen says that the formulas and rules given by me are not sanctioned by practice. My purpose in writing was largely to show that these rules in particular are overlooked in practice. Theory and practice must go hand in hand; each needs correction from the other. No system of construction was ever perfected by theory alone, and none was ever perfected by practice alone. Practice has made many test-beams with short thick rods, and these rods pull out of the concrete just as theory, or the rule given by me, would predict. This kind of practice is wasting steel that cannot develop its strength. Practice, of a construction in its infancy, is not a competent witness where alleged improvements on itself are concerned.

Mr. Morssen makes an indefinite assertion to the effect that the adhesion between steel and concrete de-

creases with the diameter of the rods embedded, and he cites French authority to back his statement, to which I have not access. No one will deny that the adhesion decreases with the diameter of the rods embedded. The tensile strength of the rods decreases with the square of the diameter of the rod embedded. Will Mr. Morssen assert that one rod 1-in. square and embedded 12½ ins. in concrete will hold with greater force than sixteen separate rods ¼-in. square embedded the same distance? The common standard of adhesion or grip of plain rods is the amount of area in contact with the concrete, and a simple calculation will show that rods of different diameters, in order to have the area in contact in proportion to their tensile strength will be embedded a given number of diameters. While it is admitted that the unit value of the adhesion is variable, as other qualities of concrete are also variable, it is generally considered that a rod embedded 50 diameters in concrete will develop its full strength, or at least its elastic limit, if the rod be surrounded with a thickness of concrete equal to several times its diameter, the concrete having set in the air.

Mr. Morssen gives an example of a "beam" of 6-ft. span. If the span were only 6 ft., would not a slab be in order? He says a good designer will never use ⅝-in. rods in a beam. As I have used ⅜-in. rods in the design of a slab I will refrain from answering this.

I have no apology to make for the contention that the proper design of reinforced concrete demands that the steel be well distributed and of comparatively small diameter, rather than being concentrated in elements of large diameter.

Mr. Morssen says that the rule given by me will induce the designer to use too large beams, and that in such beams longitudinal cracks occur between the rods. Can he cite any experience or results of tests to substantiate this?

Another dogmatic assertion of Mr. Morssen's is that well-designed beams reinforced with stirrups will not fail as shown by me though the height be greater than one-tenth of the span. I made tests on quite a number of beams with stirrups in a finished building. The principal mode of failure was just as my sketch shows. In Proceedings of the American Society for Testing Materials, Vol. IV. p. 498, Prof. F. E. Turneaure describes some test-beams which were 6 × 6 ins. and 60 ins. in span, reinforced with stirrups, spaced 3 ins. apart. On page 507 Prof. Turneaure says: "In but a few cases was the failure free from the influence of shearing stresses, the rupture usually occurring outside of the load and on a diagonal line." These beams were one-tenth of the span in height, and they had stirrups, and they failed about as my sketch shows.

The reason I did not "follow my own theory" as Mr. Morssen puts it in the girder of 20-ft. span is because it would give a clumsy beam to make its depth one-tenth of the span. Further, I wanted to give an example of a beam reinforced partially with rods curved up and anchored for their full stress at the ends, another part of the theory.

Mr. Morssen says that a steel area of 1¼% may be too expensive for the purpose. Is it too much or too little? (requiring too much concrete). I have been criticised on the ground that it is too much from alleged theoretical considerations. If Mr. Morssen will look up practice as it is exhibited in descriptions of reinforced concrete construction in the engineering papers, I think he will find that leaving out the area of the slab, as having no place in the beam, 2 or 3% of steel is not uncommon.

It is a pleasure to reply to a letter in the tone of that of Mr. John Hawkesworth, which you have kindly submitted to me. This letter is from one who is manifestly a fellow seeker after the truth. A letter in a very different tone came to me recently, touching on some of the same points mentioned in this one, from one who has not the temerity to express publicly the final judgment which he snapped on my theory and deductions.

The question of using a certain unit stress on the steel and concrete and proportioning the beam on that basis, or of using certain ultimate values and then allowing as a safe load some fraction of the ultimate capacity is too extensive to be discussed here as a general question. When confined to a single case, as reinforced concrete, it is merely a question of means; identical results may be obtained by either means.

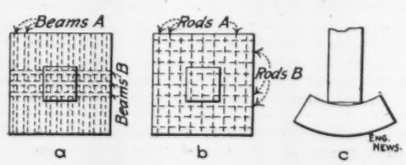
In reinforced concrete design it is convenient to use a certain factor of safety based on the ultimate strength of the parts because of the dissimilar materials dealt with and the desirability of having the same relative strength in each. In choosing an ultimate value for the steel I did not lose sight of the actual amount of the safe value. This is made clear by my first paper on the subject (Engineering News, March 15, 1906), for I there criticise the use of high elastic limit steel, because the resultant safe load on the steel when the factor of safety is applied is too great. Where is the difference between using 10,000 lbs. per sq. in. on the steel and 500 lbs. per sq in. on the concrete and using 40,000 lbs. per sq. in. on the steel and 2,000 lbs. on the concrete with a factor of safety of four?

On the location of the neutral axis of a beam or slab I have said something before in these columns. The case is one that has entirely too many complications to be settled by theory with no other data than the relative moduli of elasticity of steel and concrete. The shrinking of concrete in setting is one of the complications. The tensile strength of the concrete is another. Measurements to locate the neutral axis of beams under test have shown that it is close to the middle of the depth of the concrete beam under safe loads. I have taken it at the middle in all of my formulas. Now taking the neutral axis in the center of depth of beam and assuming that the intensity of stress in concrete varies uniformly from the neutral axis up, there remains but one factor to fix the percentage of steel, namely, the relative unit stress on concrete and steel. If this is as 1 to 20 the percentage must be 1¼. This is very simply found by the principle which Mr. Hawkesworth states and which I have given in both of my papers, namely, that the amounts of stress in steel and concrete must be equal. Any greater percentage of steel in a rectangular beam means a greater stress, relatively, on the concrete. Any less means a greater relative stress on the steel.

As to the floor slab acting as a T-beam: It would of course be allowable to use a part of the floor slab, provided it was placed at the same time as the beam, and provided the owner were forbidden to cut holes in the slab, as he might think he had a right to do. However, the T-beam method can only show to its credit a saving of concrete around the reinforcing rods, just where the concrete is needed to protect and grip the steel and to transfer the shear. I tested some beams in a building that were 3 ins. wide and were reinforced with 1½-in. square rods. Is this enough concrete to protect and grip a rod of this size or to take the horizontal shear? My tests conclusively proved otherwise.

Mr. Hawkesworth criticises my mathematical deductions on the wall footing, and states that where a cap stone or a column-base is superimposed on a footing slab, the maximum moment in the slab occurs at the center. A reinforced concrete footing would probably be surmounted by a concrete wall put in at the same time, and a column base would probably have a plinth of concrete upon which it rests, instead of being placed directly on the slab. In these cases the depth of beam would be augmented and the tension on steel diminished toward the center.

Mr. Hawkesworth gives an "old reliable" formula for the bending moment at the center of a footing. It is presumed that he does not mean that this formula expresses the bending moment at the center of a column, as this center is a vertical line and can have no section modulus. And yet this is what his reasoning seems to lead to. This is a formula for the bending moment in a row of I-beams in a grillage, at the center plane of the column or wall.



Beams A in the accompanying sketch, at (a), could be proportioned by this formula. Beams B could also be proportioned by the same. If, however, the latter spread out to the full width of the footing, those outside of the column base would be absolutely useless. There is no analogy between these steel grillage beams and the reinforcing bars as shown at (b). (I assume this is the manner of reinforcing referred to by Mr. Hawkesworth. My timid critic says this is the common way of placing the rods.) It is not even approximately correct to use the so-called old reliable formula. By that formula each set of beams takes the entire reaction and transmits it to the set above. If we assume that rods A in the reinforced concrete footing take all of the reaction, we must also assume that they give that reaction to such of rods B as lie under the column base. But this puts excessive load on those few rods, and leaves idle the rods B not under the column base. On the assumption that both sets of rods act together necessarily more of the load must be taken by the rods lying under the base, and the formula is seen to be inapplicable.

By the use of diagonal rods the upward f... on the footing at any part of the same is carried di... y to the base by the shortest route. Each part is ta... are of, and there is some excess of strength at t... ides by reason of the additional depth used in column ... es over wall footings.

The formula given by Mr. Hawkesworth, as ... ed to a wall, is based on the assumption that the wall ... is per- fectly uniform on the slab. This would be ... if the wall were a fluid or yielding body that wou... ke the shape of the deflecting footing. But when the ... ng de- flects, the tendency is to throw the load close ... e edge diminishing the bending moment. For all ord... y earth pressures the depth of footing is a large frac... of the projection beyond the wall. A considerable ... of this projection could be made in a plain concrete ... ng as- suming a low modulus of transverse strength. ... legiti- mate to make use of this surplus strength o... e con- crete to balance the small increase in the mom... within the edge of the wall, which an only partia... correct theory finds to exist.

Yours very truly,

Edward G... offrey.

Monongahela Bank Bldg., Pittsburg, Pa., Aug. ..., 1906.

THE PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES FOR 1905.

The cement industry in the United States in 1905 is the subject of a bulletin recently published by the Division of Mineral Resources of the U. S. Geological Survey, having been prepared under the direction of Mr. Edwin C. Eckel, Assoc. M. Am. Soc. C. E. Data on the production of Portland cement, grouped according to the various combinations of raw materials used in its manufacture, are shown in the accompanying table. This table is a continuation, with slight corrections, of a table published by Mr. Eckels in a review of the American cement industry for 1902-3 (Eng. News, Feb. 25, 1904).

It will be readily perceived from this table that while one-half of the total product is still made from cement rock and limestone, yet the percentage has been steadily decreasing. Likewise the marl-clay mixture shows a similar decrease in its percentage of total production. On the other hand, the percentage of the product made from a mixture of hard limestone and clay or shale has more than quadrupled in the past eight years.

The number of kilns in use naturally shows an increase, though not, however, corresponding to that of the industry itself. For example, of rotary kilns in 1902, there were 456 active, 9 idle and 46 in process of building; in 1905 there were 722 active, 23 idle, and 42 building. But along with the increase in the number of kilns, there has been a marked increase in the rate at which the plants were driven, and also in the size of the kilns. For 1902, it is stated, each active rotary kiln averaged a total output of 36,909 bbls.; for 1905 the average output was 48,118 bbls. This increase of about 30% is attributed partly to more steadily driving, and partly to the use of longer kilns. It is estimated that in 1906 an average of over 50,000 bbls. per kiln per year will be attained. The increase in the use of rotary kilns shows a marked contrast when compared with the figures for vertical kilns. In 1902 456 vertical kilns were active, 9 idle and 46 building; in 1905, 395 were active, 116 idle and none building. Only three factories in 1905 reported productions of Portland cement burned in vertical kilns.

The total capacity of American cement plants for 1905 is reckoned at 129,000 bbls. per day; it

PRODUCTION AND PERCENTAGE OF TOTAL OUTPUT OF PORTLAND CEMENT IN THE UNITED STATES ACCORDING TO TYPE OF MATERIAL USED, 1898-1905.

Year.	Type 1. Argillaceous limestone (cement rock) and pure limestone. Quantity, Barrels.	Per- centage.	Type 2 a Marl and clay. Quantity, Barrels.	Per- centage.	Type 3. Soft limestone (chalk) and clay. Quantity, Barrels.	Per- centage.	Type 4 b Hard limestone and clay or shale. Quantity, Barrels.	Per- centage.
1898	2,764,694	74.9	562,092	15.2	40,120	1.1	325,288	8.8
1899	4,010,132	70.9	1,095,934	19.4	88,200	1.6	458,000	8.1
1900	5,960,739	70.3	1,454,797	17.1	185,686	2.2	880,798	10.4
1901	8,503,500	66.9	2,001,200	15.7	495,752	3.9	1,710,773	13.5
1902	10,953,178	63.6	2,220,453	12.9	373,425	2.1	3,683,588	21.4
1903	12,493,694	55.9	3,052,946	13.7	457,813	2.1	6,338,520	28.3
1904	15,173,391	57.2	3,332,873	12.6	79,500	0.3	7,920,117	29.9
1905	18,454,902	52.4	3,884,178	11.0	235,385	0.7	12,672,347	35.9

Type 1.—Material used in all the cement plants of the Lehigh district of Pennsylvania and New Jer... and also at several Western plants.

Type 2.—Material used only in the states of Michigan, Ohio, Indiana and New York.

Type 3.—Material used in Alabama, Arkansas, Texas and South Dakota.

Type 4.—Material used at many plants throughout the United States.

a Including in the years before 1905 the product from alkali waste and clay at one plant.

b Including the product from slag and limestone.

is expected that before the close of 1906 the total possible production will exceed 140,000 bbls. per day. Comparing production by years, 1905 shows the greatest gain over the preceding year. To quote from the report:

The increase is 8,427,051 barrels of cement in quantity and $9,613 in value, which statement shows most clearly the great bettering of conditions in the cement industry in this country in 1905. The total production of cement for 1905 was 40,102,308 barrels, having a value of $35,041,533, as compared with a total production in 1904 of 31,675,257 barrels of cement, having a value of $26,031,720. The production of Portland cement in 1905 was 35,246,812 barrels, valued at $33,245,867. The production of natural cement in 1905 was 4,473,049 barrels, valued at $2,413,052. The production of puzzolan cement in 1905 was 382,447 barrels, valued at $272,614.

Some concentration of interests in the cement industry is noted, but the possibility of a trust or combination to bring about unduly high prices is dismissed as out of the question.

The pamphlet contains statistics of cement production by states with considerable descriptive matter thereon. Sections are devoted also to the imports and exports of cement by the United States, and to cement production and importation by foreign countries.

STANDARD STREET RAILWAY TRACK CONSTRUCTION FOR PAVED STREETS AT BUFFALO, N. Y.

In the new standard track construction adopted for the street railway system of the International Ry., at Buffalo, N. Y., all wood is dispensed with, and the rails are supported by a bed of concrete, in which steel ties are embedded at long intervals. The construction is shown in the accompanying cut.

A 9-in., 94-lb. girder rail is used, with a head of the semi-grooved type, the guard side of the groove being lower than the running head, so that while it protects the edge of the paving it does not (in combination with the head) form a broad track upon which wagon wheels can ride. The rails are connected at 5-ft. intervals by flat tie-bars ⅝ × 2 ins., with ⅞-in. threaded ends which pass through the rails and are secured by nuts on both sides of the web. Steel ties of the Carnegie or I-beam type, illustrated in our issue of Aug. 24, 1905, are laid at intervals of 10 ft., and to these the rails are bolted; the ties are 5½ ins. deep and 6 ft. long. The foundation is a 6-in. bed of concrete, 9 ft. wide, extending the full width of the tracks, but this is increased to 12 ins. at the ties; the ties are thus embedded in the main body of concrete and have 6 ins. of concrete beneath them. The concrete is composed of 1 part Portland cement, 3 sand and 5 broken stone. The paving between the tracks and rails is of granite blocks on a cushion bed of dry gravel. A line of blocks is also laid against the outer side of the outer rails, with a packing of cement and gravel between the rails and the blocks. The sides of the streets are paved with asphalt.

In the type of construction formerly used, it was the practice to use yellow pine ties 5 × 7 ins., 7 ft. long, spaced 5 ft. c. to c., with tie-rods 10 ft. apart; also to electrically weld the joints in the 60 ft. 9-in. Lorain girder rails. It was found that in full concrete construction the rail would cut into the ties wherever poor tamping was done in concrete under the rail, so it was considered best to use the steel ties at 10 ft. spacing. This secures a better bond between the tie and the concrete, and makes a more rigid as well as a cheaper construction, owing to the much longer life of the steel tie over the wooden tie, thereby avoiding the disturbance of the concrete base when the rail is worn out and has to be removed. The twelve-bolt standard splice-bar joint has been adopted, owing to welded joints breaking in the winter; these breakages involved costly work in putting in new 10-ft. pieces of rail. Experience has shown that with track which has been laid for a number of years and has become out of surface and line (and with pavement in poor condition) the spreading of track has developed, causing much trouble and forming a large source of expense in maintenance. It is expected that this trouble will be done away with by putting in tie-rods spaced 5 ft. instead of 10 ft. apart, while the steel tie attachments will hold the rails more securely than the spikes in wooden ties.

In regard to the semi-grooved rail, there has been no trouble from wear of the groove due to interurban cars with large-flanged wheels, and no such trouble is expected with the wheels in use on these lines, which have a 2½-in. tread and ¾-in. flange. Snow and ice cause no trouble, as the groove is of such shape that the wheel flanges push the accumulation out of the groove, making it self-cleaning.

For drawings and information of this revised system of track construction we are indebted to Mr. T. W. Wilson, Assoc. M. Am. Soc. C. E., General Manager of the International Ry.

ROAD AND STREET DUST PREVENTION IN ENGLAND.

One of the most absorbing topics before local authorities and users of and residents near the public highways in Great Britain is the prevention of the dust nuisance. This nuisance is rapidly becoming almost intolerable, with the increased use of rapidly driven motor vehicles. In a recent issue of the "Automobile Club Journal" the following statement by the Borough Engineer of Dunstable appears, regarding the tar painting of the Holyhead road in that borough:

(1) There is no street watering done for at least 10 to 14 days, until the roads are thoroughly dry.

(2) The horse broom is sent over the road before tar painting is commenced, and the road is afterwards swept by hand with soft house brooms, about 150 to 200 yds., half the width, to take off the fine dust.

(3) The tar is heated to about 75 to 95° F. and then applied by specially made tar brushes. When this space has been completed it is covered with Leighton Buzzard sharp sand or slag dust, and the traffic at once turned upon it. This soon works it to a good face. The other half of the road is then treated in a similar manner.

(4) Should there be rain, say, for half a day steadily, the work should be left for at least a week of dry weather, so that the foundation may become dry again. I find from experience that if the foundations are in the least damp, although the surface is dry when the work is done, the first wet day will show the surface of the road in a muddy state. It will, however, regain its smooth face in dry weather; but if care is taken to have the foundations dry, the muddy state will not appear in wet weather.

I find that the less water used upon the treated portion the better the work stands. Therefore I do no street watering, so that in the winter there will be no mud, thus saving a great amount of scavenging, and to prevent any dust the roads are swept once each week at 4 a. m. with the horse-broom, and the dust picked up before 8 a. m. I also prevail upon the tradesmen to put their shop sweepings into their dust-bins.

The whole of the tarred portion will receive another coat of tar in the autumn. The tar used is ordinary gas tar, but of a good quality.

In my opinion roads ought to be faced up with good granite before tar painting is commenced. They will then last longer, as the traffic appears to glide or slide over it instead of causing the grinding action, as in the ordinary macadam road. The tar painting expels the wet, thereby keeping the road dry (which is the secret in keeping the road in good condition). I do not think it needs any prophecy, as the motor traffic has come to stay to say that before long the whole of the main roads will be treated with tar paint, as the several municipal, urban and rural authorities will see that it is to their advantage to do this work, and so have no dusty roads in the summer and no muddy roads in the winter, while the cost of repairing the roads will be less than at present in consequence of less material being required.

It is stated that the tar costs 1½ cts. per Imp. gal., or a little less than 3 cts. per U. S. gal., and that 4,800 U. S. gals. "will do six acres." The total cost of tar, sand, labor, heat and supervision is given as about 1 ct. per sq. yd. The sand cost 3s. 10d. (93 cts.) per long ton; the slag dust, 5s. 6d. ($1.34). The slag dust covers twice as much area as the sand, weight for weight, and is said to put "a very good and strong face" on the work.

We find a further discussion of dust suppression in the London "Surveyor" of July 20, 1906, which reprints a paper on "Macadamized Roads and Dust." The paper was presented before the recent Bristol meeting of the Royal Sanitary Institute, by Mr. A. P. I. Cotterell.

One of the main causes of dust, the author said, is "the vital requirement of elasticity" in the macadam, which is satisfied by filling interstitial stone spaces "with smaller material, some of it gravel or sand, but most of it fine dust or mud, according to the state of the weather and the character of the road stone." The best material for filling these spaces will be one having a high specific gravity, not easily pulverized by shocks and not reduced to dust or mud by the action of the weather.

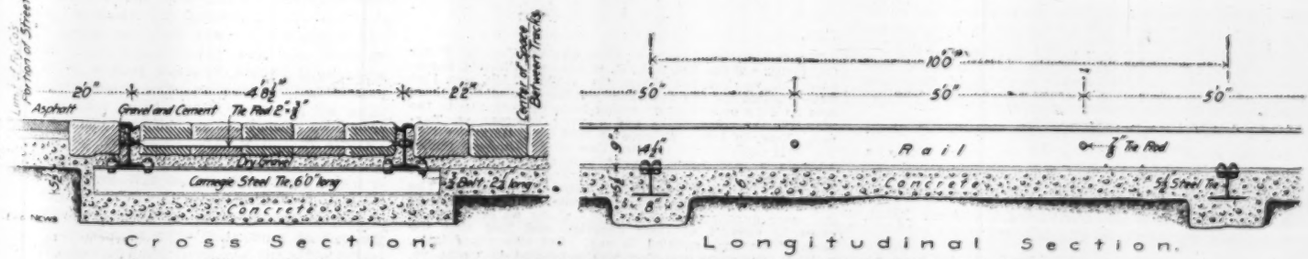
Some of Mr. Cotterell's statements regarding methods and costs of dust prevention are as follows:

In Liverpool records were kept in 1902 and 1903 of the cost of treating certain macadam roads with oil. The cost appears to have varied between ¼d. and ½d. [½ to 1 ct.] per sq. yd., according to the amount of oil used, and the total reduction in the cost of cleansing and watering was from 1.3d. to 5.5d. [2.6 to 11 cts.] per sq. yd. for a period of 21 days. Apparently the treatment resulted in a distinct saving in maintenance as well as reduction of wear, but, on the other hand, the oil did not form a very pleasant surface for traffic and the smell was complained of. In 1903 the oil was applied more carefully and renewed at intervals of three weeks, and the cost was stated to be .0022d. per sq. yd. per day, as compared with .0033d. per sq. yd. per day, the cost of ordinary street watering.

Treating the roads with a watering solution may be possible in urban, but as a rule it is altogether beyond the means of rural districts, and another method must be found. The dust nuisance has been successfully tackled by coating newly rolled metalling with boiling tar and pitch. Immediately after the road is formed the tar and pitch is applied in a flat stream from a watering pot. It is then dressed with fine flint grit and allowed to stand a day or two for consolidation before the traffic passes over it. Even with mendip limestone, which is notorious for giving off dust, this method has been found to be successful.

Another example of the second way of overcoming the dust question is the use of tarred macadam. This has been tried for some years with more or less successful results. Tarred slag appears to have answered well in some of the busy thoroughfares of London. The tar, as in the previous case, is applied hot, the slag being also heated to dryness. Apparently better results have been obtained with slag than with limestone or basalt.

A NEW TRANSCONTINENTAL RECORD for automobiles has been established, the time from San Francisco to New York being 15 days, 1 hr. 50 mins. The trip was made in a 30-HP., six-cylinder Franklin car by Messrs. L. L. Whitman and C. S. Carris, who two years ago established the former record of 32 days, 23 hrs. with a 10-HP. car. Various delays due to accidents and detentions by local authorities prevented an even more remarkable record.



STANDARD TRACK CONSTRUCTION FOR PAVED STREETS; INTERNATIONAL RY., BUFFALO, N. Y.
T. W. Wilson, M. Am. Soc. C. E., General Manager.

THE LIABILITY OF WATER COMPANIES FOR FIRE LOSSES.

Although it is a pretty clearly established principle in law that a municipal corporation is not liable for fire losses due to its negligent failure to furnish a proper water supply, the question is much more doubtful as to the like immunity of a private corporation under contract with a municipality to provide water for general fire purposes. The subject is ably discussed by Prof. E. R. Sunderland, of the law department of the University of Michigan, in the "Michigan Law Review" for April, 1906; his article is considerably condensed in the following.

Where there is a direct contract between the consumer and the water company for an adequate water supply for fire purposes, there is no doubt as to the liability of the company. But in the situation to be discussed, the case is radically different: the contract is made by the municipal corporation with the water company, and an individual attempts to sue for losses resulting from a breach of it.

In the earliest American case on the general question of the liability of water companies for losses due to fire, that of Nickerson vs. Bridgeport Hydraulic Co. (1878: 46 Conn. 24, 33 Am. Rep. 1), the court held the want of privity fatal to the action: " . . . there was no contract relation between the defendants and the plaintiffs, and consequently no duty could be the basis of a legal claim." The same question was similarly decided by the Supreme Court of Tennessee in Foster vs. Lookout Water Co. (1879: 3 Lea 42); by the Supreme Court of Georgia in Fowler vs. Athens City Water-Works Co. (1889: 83 Ga. 219); and in the cases of Beck vs. Kittaning Water Co. (1877: Penn., 11 Atl. 300), Boston Safe Deposit Co. vs. Salem Water Co. (1899: 94 Fed. 238), and Wainwright vs. Queens County Water Co. (1894: 78 Hun. 146).

However, privity, in the strict legal sense, is not always necessary as the foundation for a suit on a contract. The leading case on this question of the right of a third party to sue on a contract is Vrooman vs. Turner [(1877), 69 N. Y. 280].

In this case the court laid down the rule that there were two requisites essential to the right, (1) an intention on the part of the promisee to secure some benefit to the third party, and (2) some privity between the promisee and the party to be benefited, and some duty or obligation owing from the promisee to the third person which would give the latter a legal or equitable claim to the benefit of the promise. Respecting the necessity of the first of these requisites, there is practical unanimity of judicial opinion. As to the second requisite there is much conflict. Many authorities hold that it is wholly unnecessary.

In regard to the first requisite mentioned above, there have been a number of cases in which the property owner was not allowed to recover on the contract, on the ground that there was no intention on the part of the city to secure a benefit to the property owner. The article continues:

This view is expressed in Akron Water-Works Co. vs. Brownless (1895:10 Ohio C. C. 620); House vs. Houston Water-Works Co. (1895:88 Tex. 233, 28 L. R. A. 532); Bush vs. Artesian Hot and Cold Water Co. (1895: Idaho, 43 Pac. 69); Eaton vs. Fairbury Water-Works Co. (1893: 37 Neb. 546, 21 L. R. Q. 653); Wainwright vs. Queens County Water Co. (1894:78 Hun. 146); and Wilkinson vs. Light, Heat and Water Co. (1900:78 Miss. 389). In these cases the contracts merely provided for the supplying of water for general fire purposes. The Supreme Court of Texas said, in the House case: "It was not made for the purpose of benefiting him [the plaintiff] or the class to which he belongs. The object and purpose of making the contract was to keep water in the mains which the city might apply to use in the public fountains, by flushing the gutters, or in extinguishing fires in case a conflagration should occur." And the Supreme Court of Idaho said, in the Bush case: "There is nothing in the contract in this case which intimates that any breach of contract between the city of Boise and the defendant was to inure to the benefit of any citizen who might consider himself aggrieved."

On this point, however, the courts of Kentucky, North Carolina and Louisiana take a directly contrary view. For example, in the case of Planters' Oil Mill vs. Monroe Water-Works and Light Co. (1900: 52 La. Ann. 1243), the court declared, in effect:

Municipal governments, while legal entities, are no more than convenient regulations instituted by the people, that they may act in their aggregate character to secure their larger protection and happiness. Municipalities are the people acting in their corporate capacity. It was the people's money that was paid the water company; it was for the benefit of the people that the promise was made on part of the company to supply water for extinguishing fires. If it were to the public that the promise of the contract was made, then it was to "the public as composed of individual persons." The municipality was but the agent of the public as thus composed. Its acts in the matter of the contract under consideration were chiefly fiduciary. The beneficiaries are the corporators. It will not do to say the water company owes them no duty.

This last opinion Prof. Sunderland quotes with approval as expressing "a very sensible and reasonable view." He says further:

Everyone knows that the people vote and pay taxes for public water rates solely because they wish protection for their property. The more valuable their property the more ready are they to pay for fire protection. To suppose that the voter has in mind that invisible, intangible, imaginary "general public" which owns no particular property when he authorizes his agent, the city government, to grant franchises and pay large sums of money for fire hydrants and fire pressure, is absurd.

In these cases where the property owner is denied the right to sue the water company, on the ground that he is not the intended beneficiary, it is quite possible that the courts have confused two things which are quite distinct. As suggested at the outset, a city operating a water-works system cannot be sued for fire losses; the reason is that it is exercising a governmental function delegated to it by the state. Along with this delegated function goes the immunity of the state from suits by citizens. But it is the governmental character of the function which creates the exemption, not the nature of the beneficiary, as some of the cases seem to indicate. It does not therefore follow that because the city is not liable to individuals, a water company which performs the same acts is also not liable.

As a fact the city, when operating water-works, really acts for the same beneficiary as the water company. Both act, and must act, for the property owners of the city. But when the city so acts it is a discretionary agent of the state, and simply cannot be sued; while the water company does not represent the state and enjoys no such exemption. To hold, as some of the cases cited do hold, that the exemption of the city from suit by individuals is due to the public and general character of the beneficiary, and that therefore the water company, which serves the same purpose, is also exempt, is to overlook the very basis of municipal non-liability. The question is not one of beneficiaries at all, but of a technical exemption from suit, granted, on grounds of public policy, to cities, but denied to private corporations.

In another group of cases, the contention that the property owners were not intended to be the beneficiaries, could not be raised. For to preclude the courts from taking this position, cities began to insert into their contracts an express provision that, in case the water companies neglected to furnish sufficient water for fire purposes, they should be liable to all persons whose property suffered damage by reason of the inadequate supply. But in these cases the courts took refuge in the second of the two requisites indicated in Vrooman vs. Turner, claiming that no duty or obligation is owing from the city to the property owners which would support the property owners in an action against the water company. All these cases were decided against the property owners on this ground. If, as these cases hold, the second requisite of Vrooman vs. Turner is necessary, they were probably rightly decided; although it might still be questioned whether there is not such a duty owing from a city to its property owning citizens as will give them the right to sue on a contract made for their benefit. A number of cases, at least, seem to point to this conclusion. If, however, the second requisite of Vrooman vs. Turner is not necessary, the decisions in the group of cases above cited rest upon a very doubtful foundation.

The two Missouri cases of Housman vs. Trenton Water Co. (1893: 119 Mo. 304, 23 L. R. Q. 146) and Phoenix Insurance Co. vs. Trenton Water Co. (1890: 42 Mo. App. 118) were decided for the defendant on the ground that there was no duty or obligation owing from the promise to the plaintiff, the court citing and quoting Vrooman vs. Turner. Now, in 1898, the case of Hicks vs. Hamilton (144 Mo. 495) came before Division One of the Supreme Court, wherein a mortgagee brought suit against a remote grantee who had promised his grantor to pay the mortgage debt, the said grantor not being liable for it. The court said that Vrooman vs. Turner involved precisely the same question, cited both the above water company cases in support of their decision, and held that the plaintiff was not entitled to sue. But two years later, in 1900, the same question was presented in Crone vs. Stinde (156 Mo. 282), and the court in banc expressly overruled the Hicks case, holding that, "The consideration passing between the two contracting parties, by which one of them promises to pay a third [illegible] available to the beneficiary as if he himself [illegible] consideration." And it was intimated that [illegible] ter company cases would have to go by the [illegible]

In Nebraska, also, in the case of Hare [illegible] (1895:45 Neb. 809), the same doctrine respecti[illegible] of a mortgagee to sue, was approved, the co[illegible] "It is an established rule of law that where [illegible] a promise to another for the benefit of a th[illegible] such third person may maintain an action [illegible] promise, though the consideration does not m[illegible] from him." This case, having been decided af[illegible] of Eaton vs. Fairbury Water-Works Co. (1[illegible] 546, 21 L. R. A. 653), overrule the latter i[illegible] so far as it is based on the lack of a duty o[illegible] owing from the city to the property owner. [illegible] sylvania case of Beck vs. Kittanning Water [illegible] Penn. 11 Alt. 300), is inconsistent in pri[illegible] Merriman vs. Moore (1879:90 Pa. St. 78), wh[illegible] a mortgagee to sue a remote grantee on a pr[illegible] for his benefit to a grantor who is not liable [illegible] the late case of Tweeddale vs. Tweeddale (190[illegible] 517), the broad doctrine was laid down that " [illegible] person for a consideration moving to him fro[illegible] promises to pay to a third person a sum of m[illegible] law immediately operates upon the acts of th[illegible] establishing the essential of privity between the [illegible] and the third person requisite to binding cont[illegible] lations between them, resulting in the immedia[illegible] lishment of a new relation of debtor and cre[illegible] gardless of the relations of the third party to t[illegible] diate promisee in the transaction."

In numerous other cases, including th[illegible] Kentucky, North Carolina and Louisian[illegible] mentioned above, the courts have held that [illegible] authorize an action by a taxpayer agai[illegible] the water company, the second requisite of Vroo[illegible] man vs. Turner is not at all necessary. With reference to this branch of the question, therefore, Prof. Sunderland concludes

that the better rule does not require any duty or obligation owing from the promisee to the third person, and that when once it appears that the contract was intentionally made for the primary benefit of a third person, that person is ipso facto entitled to sue upon it.

In order to avoid the difficulties of a suit on contract, it has been attempted, in several cases, to base the action against the water company on tort. But this theory has received little or no support from judicial decisions.

Another case demands attention, one in which the loss was suffered, not by an individual taxpayer, but by the city itself. In the very recent case of Ukiah vs. Ukiah Water Co. (1904: 142 Cal. 173), the property of the city was damaged by fire by reason of the failure of the water company to furnish a sufficient supply of water. Here, although at first view, the question of privity would seem eliminated, yet the decision of the court was against the city on the ground

that the contract was not for the protection of any particular property or person, but was for general benefit of all the property and persons within the municipal limts . . . the defendant assumed no obligation regarding plaintiff's property different from that assumed by it regarding all of the other property within the town; and the plaintiff, as a property owner, is without right of action.

If the premises are correct in this case, Prof. Sunderland says, the conclusion is substantially sound. But, as pointed out above, the assumption that a private water company has the same immunity from right of action as a municipality maintaining water-works, does not seem tenable.

Finally, Prof. Sunderland says, the question of the liability of water companies for fire losses, as should be clear from the above analysis, is merely one phase of the larger question respecting the right of a third person to sue upon a contract.

A CASE OF VERY CHEAP HYDRAULIC POWER was mentioned by Prof. K. Birkeland, of the University of Christiania, Norway, in a paper recently read before the Faraday Society (Great Britain) at London, England. In describing the plant for producing nitric acid and nitrates from atmospheric nitrogen by means of his disk-shaped electric arc flame, he stated that the electric power (5,000-volt alternating current) costs the company only 25s. (= $6.08) per electric horse-power-year. The cost of *producing* this power, he stated, is only 11s. (= $2.67) per electric horse-power-year. The output of the furnaces using his process is said to be as a minimum 200 kg. anhydrous nitric acid per kilowatt-year. Then at the price of 25s. per E. HP.-yr., or 33.3s. per KW.-yr., the power-cost per ton (1,000 kg.) of acid appears to be 67s., or with a yield of 600 kg. per KW.-yr. it would be 55.5s. per ton. Prof. Birkeland quotes a total cost of [illegible] per ton of acid, so that the power-cost makes up well over half of the cost of production. The remarkably cheap power available for the process (at Notodden, Norway) is evidently the prime factor in making the process commercially applicable.

SPECIFICATIONS FOR TAR MACADAM, OTTAWA, ONT.

Tar macadam at Ottawa, Ont., according to Mr. Newton J. Ker, City Engineer, is nearly equal to bitulithic pavement or macadam, and only about half as expensive. The specifications for tar macadam at Ottawa, as prepared by Mr. Ker (dated Oct. 10, 1903), are as follows, in so far as they relate to the tar macadam proper:

(12) Upon the sub-grade so prepared shall be laid a foundation course as shown on the drawings, and in the following manner, viz: A course of limestone spalls, 8 ins. in thickness. The quality of the stone must be approved by the Engineer. No particle of stone shall be more than 6 ins., and not more than 5% of the stone shall be less than 2 ins. in length or breadth. The stone is to be placed by hand and roughly broken with sledges, then rolled with a 15-ton roller until thoroughly consolidated so as to form a compact layer of stone 8 ins. thick. The surface must conform to the requisite lines and levels shown on the drawings, after the rolling has been completed.

(13) Upon the above foundation course is to be laid an intermediate course or layer of clean broken limestone 3 ins. in thickness. No stone or particle is to be less than ¾ in. or more than 2½ ins. in length or breadth. After this course has been evenly spread over the street it is to be rolled so as to form a compact layer of stone 3 ins. thick, and the surface must conform to the line and levels shown on the drawings after the rolling has been completed.

(14) Upon the above intermediate course of clean broken limestone is to be laid a course of good, hard and tough limestone, no particle of which is to be more than 2 ins. or less than ¾ in. in length or breadth. This course is to be coated with a mixture of pitch and tar, while warm and dry (as specified in Clause 22) and is to be laid while still warm. When delivered on the street it is to be at once raked and spread to conform to the required cross section, and immediately rolled with a 5-ton roller so as to form a compact layer of 3 ins. in thickness when the rolling is completed. Special attention must be given this course to make the surface conform in every particular with the cross section, lines and levels shown on the drawings and as laid down by the engineer.

(15) After the above course of tarred limestone is completed to the engineer's satisfaction a top layer of hard limestone of the toughest and best description, screened so as to be free from dirt, dust and foreign matter, and as uniform in size as possible, is to be laid. No particle is to be more than ⅝ in. and not more than 5% of the stone shall be less than ¼ in. in length or breadth. This course is also to be coated with a mixture of pitch and tar while still warm and dry, and is to be laid while warm. The surface shall then be at once evenly raked, rolled with a 5-ton roller, repaired, brought fully up to grade and true to cross-sections wherever required and then re-rolled until firm, compact and true.

(16) A thin but sufficient layer of approved limestone dust is then to be evenly spread over the whole surface and thoroughly rolled with a 15-ton roller, so as to carry the dust into all interstices. More limestone is to be added where and as required, as the rolling progresses, so that the whole surface is completely and evenly covered with a uniform coat of limestone dust when finished, of not less than ⅛ in., nor more than ¼ in. in thickness after the roller has ceased. Brooms must be used in this process if required by the engineer. The surface of the top course of stone must not in any place be below the lines and levels shown on the cross-section drawing nor be more than 1 in. above the same, no uneven places will be allowed, and all such must be remedied, as and when the engineer directs, and then thoroughly re-rolled until smooth, even hard and true.

(17) All stone to be tarred must be thoroughly dried by heating on an iron floor under which are flues from a fire; by piling it on and around an iron cylinder or in any other manner approved of by the engineer. All moisture must be driven out. The stone must be allowed to cool to a moderate degree of heat so that it can be comfortably held in the hand, before coating it with tar.

(18) The tar must be refined coal tar, free from all foreign substances, and shall contain upon analysis not less than 75% pitch, nor more than 2% water, nor more than 5% of the lighter oils distilling under 200° C. It must be quite thick at 70° F., and have a specific gravity of 1.20. To insure the above characteristics the crude tar should be previously heated to 250° F.

(19) The paving pitch must be tenacious, not brittle at 70° F., insoluble in water, specific gravity of about 1.18, and have a melting point not under 220° F.

(20) One part paving pitch shall be mixed with two parts refined coal tar. The engineer reserves the right to vary the proportions of this mixture, so as to increase the proportions of pitch as much as 20% if he deems necessary, without extra compensation to the contractor.

(21) The tar and pitch must be heated in separate kettles and then thoroughly mixed in the prescribed proportions in a third kettle before being poured upon the stone.

(22) The stone after being dried and while still warm is to be placed on a metal concrete platform, then thoroughly coated with the mixture as described in Clauses 20 and 21, the stone being turned with shovel in the same manner used in mixing concrete. Enough tar and pitch must be used to coat entirely each particle of stone, but no more. The stone shall then be immediately conveyed to the street and must be laid and rolled while still warm.

(23) All tar and pitch will be subject to an analysis which shall not only conform to the specifications, as given in Clauses 18 and 19, but also meet with the approval of the engineer in every respect. Samples of tar and pitch proposed to be used must be submitted to the engineer at least ten days before it is required in the work.

(24) The work shall be carried on in warm weather, and all work must be suspended during wet weather.

AN EARTHQUAKE WRECKED VALPARAISO, in Chile, and a large extent of surrounding territory, on Aug. 16 and 17, 1906. The first shock was felt at 7.50 p. m. of Thursday, Aug. 16, and for several days thereafter shocks of varying degrees of violence occurred. The city of Valparaiso, it appears from the brief and vague reports which have arrived, was at the center of the disturbance, and it was wrecked in a degree closely comparable to that of San Francisco's destruction last April. The water piping of Valparaiso was broken in a great number of places, so that the lower parts of the city were flooded. Fires broke out and did great damage, though probably these were by no means of the scale of San Francisco's conflagration, since the first shock is reported to have come in the midst of a heavy rainstorm. The number of dead will reach several hundred, at least, on a total population in Valparaiso of about 150,000. The places outside of Valparaiso which have been reported affected are generally within a radius of 50 miles from that city, and are in the coast region, though serious damage is reported also from Petorca, a city of 30,000 inhabitants lying at the foot of the Andes about 100 miles northeast. The nitrate regions of northern Chile are unaffected, it seems, but an anomalous case is the reported destruction of Arica and Tacna, north of Iquique and over 800 miles north of Valparaiso. Santiago, 75 miles southeast of Valparaiso, is somewhat damaged but is not in serious trouble. The Chilean earthquake shocks were felt by all seismographic observatories in the United States. A "tidal wave" five feet high was reported from the Hawaiian Islands on Aug. 17. The naval observatory at Valparaiso gave public warning of a coming earthquake a day before.

FLOODS IN WESTERN TEXAS, due to heavy rains and local "cloud-bursts," did much damage in the period around Aug. 11, and killed some 50 people. Numerous washouts of railway embankment occurred, and a number of bridges were washed out. While the worst conditions are in the western part of Texas, many points in Texas, Arkansas and the northern border of Mexico are affected.

ALL RAILROADS ENGAGED IN INTERSTATE Commerce have been ordered by the Interstate Commerce Commission to report to the Commission on or before Sept. 1, 1906, the total number of freight cars owned on Aug. 1, 1906, together with the number of such cars equipped with air-brakes. The purpose of this order is to ascertain what progress has been made in complying with the order of the Commission issued Nov. 15, 1905, and effective Aug. 1, 1906, requiring 75% of all cars used in a train to be fitted with air-brakes. In addition to this order of the Commission, the Master Car Builders' Association has issued a rule requiring all cars offered in interchange after Sept. 1, 1906, to be equipped with air-brakes.

PROPOSALS TO FURNISH CHINESE LABOR to be used upon the Canal Zone, Isthmus of Panama, have been invited by the Isthmian Canal Commission. Bids will be received at Washington, D. C., up to Sept. 20, 1906. They must be expressed in terms of hourly wages, payable in gold or its equivalent, for the labor of 2,500 or more Chinese laborers for a period of two or more years, to be furnished on or before Jan. 7, 1907. It is provided that the working day shall be ten hours, and that work done on Sundays or holidays shall be paid for at the rate of time and half time. The holidays named include those ordinarily observed in the United States, and in addition the first and last days of the Chinese New Year. The contractor must assume all liability for damages or indemnity for which the laborers or their families may maintain a legal claim. Families and children will be allowed to accompany laborers "in the proportion of 15% of the total number of laborers employed at any time." All laborers shall be subject to physical inspection and personal identification at ports of embarkation and upon arrival at the Canal Zone. The cost of transportation of the laborers from China and for their return shall be borne by the contractor, also the cost of their food, clothing, etc., during this period and during the term of employment in the Canal Zone. The contractor will be bound to permit neither slavery or involuntary servitude on the part of the laborers, and to give them just and humane treatment. He must provide foremen in number not less than one to each 250 laborers, and a physician and an interpreter for each 500 laborers, together with cooks, barbers, etc., all to be of the same nationality as the laborers. The Commission undertakes to furnish, without charge, lodgings, fuel and water, transportation over the Panama R. R., medicines and medical treatment, hospitals and burial grounds.

AN "AIR LINE RAILROAD" from New York City to Chicago by way of Pittsburg, has been projected. Operation by electricity is contemplated. The route surveyed is some 805 miles long, the absolute distance between the two cities being 748 miles. Mr. Joseph Ramsey, Jr., formerly president of the Wabash R. R., who is promotor of the new project, estimates the cost of the Pittsburg-New York section at $75,000,000 to $100,000,000. Papers have been filed at Harrisburg, Pa., for the consolidation of three railroads to be constituent parts of the projected "Keystone Air Line," but the aggregate actual mileage of these is but 85 miles.

CONSTRUCTING ENGINEERS are wanted by the U. S. Reclamation Service, which has requested the Civil Service Commission to hold an examination on Oct. 1 for the purpose of securing an "eligible" list. Such engineers should have had experience in both tunneling and concrete masonry, and would be paid salaries at the start ranging from $150 to $250 per month, depending upon the ability of the engineers finally selected and the character of their assignments. It is stated that the examination will be based on the probability that experienced constructing engineers will be somewhat "rusty" on theoretical matters outside their daily practice. Consideration will be given to evidences of ability to handle men and materials in an efficient manner. There is no set place for the examination; instead, candidates will be permitted to prepare papers and send them to the Commission for examination. In general form, the examination will be similar to one held on April 1, 1904.

COMPETITION AMONG BIDS on different kinds of paving materials has been declared legal by the Maryland Court of Appeals in a recent opinion which reversed the decision of the lower courts in some paving cases at Baltimore. Bids had been received on three kinds of paving material, sheet asphalt, asphalt blocks and bitulithic; of these the bid on sheet asphalt was the lowest. The city did not want to pave all the streets with sheet asphalt, but it was declared to have no right to award the contract to any but the lowest bidder. Furthermore, when a contract was awarded for paving with bitulithic its right to use a patented material was questioned. On both these points the Court of Appeals rendered a decision in favor of the city. The Court held that, after receiving bids on these different paving materials, the city might first decide which material it would use, and then accept the lowest bid in that class.

THE NANKAI RY. OF JAPAN, the first railway in that country to be electrified and equipped for high speed, is to be protected with the "Young System" of automatic block signals, manufactured by the General Railway Signal Co. This is the same kind of a system as is being installed in the electric zone of the New York Central & Hudson River R. R. (Eng. News, Vol. LV., p. 648) and the New York, New Haven & Hartford R. R. at New York City. The blocks will average about half a mile in length and each will be provided with a home and distant signal. The signals will be operated by alternating current supplied from a special single-phase transmission line running the entire length of the road. This line will be operated at 2,200 volts and 60 cycles, the lights and motors for operating the signals being supplied from 2,200 to 50 volt stepdown transformers. This railway, comprising 9½ miles of double track, is to be operated by direct current on the two rail system; that is, both rails will be used for returning the propulsion current. Therefore, in order to use the rails for the return of the signal current, reactance bonds will be installed. Takota & Co. have the contract for the equipment of the road.

A CAUSEWAY ACROSS GALVESTON BAY has been projected by the city of Galveston, and plans and estimates for the structure have been prepared by James Stewart & Co., of New York City. The plan contemplates a permanent structure, 140 ft. wide and 10,850 ft. long, connecting the Island of Galveston with the mainland at Virginia Point; it provides for three steam railway tracks, two electric railway tracks, a highway 30 ft. wide, a footwalk 10 ft. wide, and a space of 10 ft. width for water mains. The estimated cost for this

structure, including bascule bridges, is $1,450,000; eliminating one steam railway track and one electric railway track, the cost is figured at $1,390,000. The causeway is to be built so as to permit the running of interurban cars at full speed while crossing it.

THE CHICAGO TUNNEL SYSTEM built by the Illinois Tunnel Co. was opened for freight traffic on Aug. 15. At the freight houses of different railways oval shafts have been sunk and fitted with platform elevators for handling the tunnel cars, which are of 2 ft. gage. Each freight house has two shafts, one for cars with inbound freight and the other for cars with outbound freight. A 24-in. gage track is laid on the floor so that the empty cars can be reloaded and run forward to the outbound shaft. There are now about 40 miles of tunnel, and the trains are handled by electric locomotives taking current from overhead wires. Mr. George W. Jackson is Chief Engineer.

THE PATHFINDER DAM SITE has been practically all laid bare, ready for preparing the bed rock for the masonry. An excellent foundation is disclosed. As many of our readers know, the Pathfinder dam will be located in Wyoming and will form a part of the North Platte irrigation project of the U. S. Reclamation Service. An article on the dam and calculations involved in its design was published in our issue of Aug. 10, 1906.

THE NEW YORK, NEW HAVEN & HARTFORD R. R. has, according to press reports, transferred all its trolley lines to the New England Security Investment Co., a voluntary association formed to take over these lines. This trolley system makes a network of electric roads between New York City and Boston, and comprises in the aggregate more than 600 miles of track. The cause of the transfer is said to be the introduction of a bill in the Massachusetts Legislature intended to prevent, in that state, the continuance of the control of trolley lines by steam railroads.

THE LIMIT TO ITS LIGHTING CHARGES of 5 cts. per KW. hr., which was forced upon the Columbus Ry. & Lighting Co. by an ordinance of the City Council of Columbus, has been declared unconstitutional by the U. S. Court at Cincinnati. It is said that the evidence showed that such a rate would require the company to furnish electricity at cost to 75% of its patrons, and at less than cost to most of the others. An injunction against the council was therefore made permanent.

A RETURN-AIR PUMPING SYSTEM with a capacity of 1,000 gals. per min. has been installed by the Chattanooga Coal & Iron Co., of Chattanooga, Tenn., for obtaining its water supply from the Tennessee River. The operation of the return-air system of pumping was explained in the course of an article on "Recent Extensions of the Employment of Compressed Air," by Mr. Frank Richards in our issue of July 26, 1906. The pumping plant consists of two Ingersoll-Rand Class R C air compressors, having 16-in. stroke and 12 and 16-in. steam and air cylinders, respectively. The return-air system discharges into a series of settling tanks and thence into a cistern. The water is pumped from this cistern into a stand-pipe by a direct-acting steam pump. These settling tanks are necessary because the water of the river is extremely muddy.

THE PAN-AMERICAN RAILWAY SCHEME has once again been raised from oblivion by the report of the special railroad committee at the Pan-American conference held at Rio Janeiro, Brazil. Of the total distance of 10,400 miles intervening between New York and Rio Janeiro, all but 3,059 miles, according to this report, is already provided with railways, or construction thereon is now under way. The committee recommends that the portion of the projected trunk line that yet remains uncompleted be constructed by the joint contributions of the countries to be benefited. The cost is estimated at $185,000,000. The members of the committee, appointed four years ago at the conference at Brazil, were Messrs. Henry G. Davis, of West Virginia, chairman; A. Lazo-Arriaga, Chas. M. Pepper, Andrew Carnegie, and J. D. Cassasus, the last named Mexican Ambassador to the United States. Mr. A. J. Cassatt, president of the Pennsylvania system, had been chairman, but resigned at the end of a year under pressure of other duties. A report on the same project made in 1904 by Mr. Chas. M. Pepper, appointed as commissioner for that purpose by President Roosevelt, was commented on in our editorial columns of March 24, 1904.

A HIGH-SPEED PASSENGER LOCOMOTIVE, specially designed with a view to obtaining a speed of 94 miles an hour with light trains, has been built by J. A. Maffei, of Munich, Germany, to the designs of Mr. Weiss, Superintendent of Motive Power of the Bavarian State Railways. It is of the 4-4-4 type, a trailing truck behind the firebox taking the place of the single trailing axle in engines of the Atlantic or 4-4-2 type. It is a four-cylinder compound, with inside high-pressure cylinders, and all the cylinders are connected to the first driving axle. Piston valves are used, placed above the cylinders, and the four valves are driven by two sets of Walschaert valve gear from the main axle. At each end of the low-pressure valves are puppet valves which open to admit live steam to the low-pressure valve chambers until the cut-off is reduced to 70%. A novel feature is that bar frames of the American type are used. The smoke-box has a conical door, and tapering extensions are fitted in front of the cylinder saddle, smokestack, dome and cab. The principal dimensions are as follows:

Driving wheels	7 ft. 2⅝ ins.
Truck wheels	3 ft. 3½ ins.
Wheelbase, engine	38 ft. 4½ ins.
Wheelbase, engine and tender	69 ft. 7½ ins.
Length of engine	45 ft. 2 ins.
Length of engine and tender	69 ft. 4 ins.
Weight, on driving wheels	70,528 lbs.
On front truck	60,610 lbs.
On rear truck	48,488 lbs.
Total engine	179,626 lbs.
Cylinders, h. p.	16½ × 25²⁵/₃₂ ins.
Cylinders, l. p.	24 × 25²⁵/₃₂ ins.
Boiler, diameter	5 ft. 6⅞ ins.
Working steam pressure	200 lbs.
Tubes, 208; diameter inside	2 ins.
Tubes (superheater), 18; diameter inside	5 ins.
Tubes, length	10 ft. 1 in.
Heating surface, ordinary tubes	2,130.5 sq. ft.
Superheating tubes	400.0 sq. ft.
Fire-box	177.5 sq. ft.
Total	2,717.0 sq. ft.
Grate area	50.5 sq. ft.
Coal in tender	17,632 lbs.
Water in tender	5,730 gallons.

THE ROAD IMPROVEMENT work of the State Highway Commission of Illinois is making satisfactory progress, much of the work being educational. About fifty stations have been established for recording traffic on country roads. On roads approaching two large country towns, one having macadam and the other dirt roads, the traffic in both cases was about 250 teams per day in good weather; during the wet season the traffic continued nearly the same for the town reached by good roads, while on the one reached by dirt roads the traffic dropped to about 80 teams per day. As an instance of the exceptional traffic due to fairs, circus performances, etc., it was found that on circus day in a country town the normal traffic of 250 to 300 teams per day on a given road increased to about 1,250 teams. Investigations as to the cost of work, etc., are being made by some engineering students of the University of Illinois who have been employed on the work during the summer. Various experiments are being made with the local materials available in certain districts. To prevent the "picking-up" of macadam by the sticky black mud carried upon it from adjacent earth roads by the wheels of wagons, one piece of road is to be graded with cement; screenings will be immediately spread and rolled in by a steam roller. The State is now building a stone-crushing plant at Joliet, Ill., with a capacity of 500 tons per eight-hour day. This and some of the experimental pieces of road are to be advertised by immense signs visible from the railways, so as to indicate to the traveling public what is being done. The work is under the direction of Mr. A. N. Johnson, State Highway Engineer, Springfield, Ill.

THE KEOKUK DAM AND WATER POWER project on the Mississippi River at Keokuk, Ia., provides for a dam 30 ft. high and 6,000 ft. long and a power-house 1,800 ft. long with 47 generators having an estimated capacity of 120,000 HP. The project has the sanction of Congress, and will improve the navigation of the Mississippi River at that point by substituting a lake and a single lock of 30-ft. lift for the present canal, ten miles long, with three locks. The whole of the present government works (locks, canal and embankment) will be submerged under 10 to 20 ft. of water; these present works cost about $4,500,000. The project is now under study, with a large corps of engineers and surveyors in the field estimating land damages. The engineer is Mr. Hugh L. Cooper, 60 Wall St., New York.

PERSONALS.

Mr. George Craig has resigned as Assistant City Engineer of Omaha, Nebr.

Mr. Homer Hamlin has been appointed City Engineer of Los Angeles, Cal., to succeed Mr. Harry F. Stafford, deceased.

Mr. C. O. Vandeventer has been appointed Chief Engineer of the United Railways & Electric Co. of Baltimore, Md., to succeed Mr. Daniel B. Banks.

Mr. John W. Ash has resigned his position as Assistant Engineer of the Southern Ry. and opened offices at Austell, Ga., as Civil Engineer and Contractor.

Mr. James S. Harlan, of Chicago, has been appointed seventh member of the Interstate Commerce Commission, which completes the personnel of the board.

The following changes have taken place in the personnel of the Reclamation Service: Mr. John Stobo and Mr. John M. Roberts, assistant engineers, have resigned.

Mr. Alexander J. Taylor, Superintendent of Public Parks of Wilmington, Del., has been appointed Engineer in Charge of Sewers of that city, to succeed Mr. George Rommel, Jr., resigned.

Mr. E. C. Burgess has been appointed Acting Engineer, in charge of construction, of the St. Louis, Brownsville & Mexico Ry., with headquarters at Corpus Christi, Tex., to succeed Mr. W. P. Homan, resigned.

Mr. D. C. Henny, of the U. S. Reclamation Service, has been made Supervising Engineer for California, excepting that portion of the state including the Colorado River and Yuma project, which has been assigned to L. C. Hill, Supervising Engineer for Arizona, and the Owens Valley, which is under the charge of L. C. Taylor, Supervising Engineer for Nevada. Messrs. Henny and Hill succeed Mr. J. B. Lippincott, resigned.

Obituary.

J. Rogers Barr, General Manager of the Lexington & Eastern Ry., died at Lexington, Ky., Aug. 18.

Harry M. Gates, a civil engineer of Columbus, O., died at his home in that city Aug. 15 of heart disease.

Michael Reilly, a retired railroad contractor of Lancaster, Pa., died at his home in that city Aug. 14, aged 73 years.

Michael McCormack, Organizer and first President of the Sea Beach R. R. Co., died at his home in Brooklyn, N. Y., Aug. 17, aged 75 years.

James Beynon, Manager of the American McKenna Process Co.'s plant for re-rolling old rails, died at Joliet, Ill., Aug. 13. He was born in Wales.

Mr. I. W. Huffaker, of Wheatland, Cal., Assistant Engineer in the U. S. Reclamation Service, was drowned at Fallon, Nev., while in swimming in one of the canals of the Truckee-Carson Project.

James Dredge, M. Inst. C. E., Joint Editor of "Engineering," died at London, Aug. 15. Mr. Dredge was Royal Commissioner to the Centennial Exposition at Philadelphia in 1876, and to the World's Fair at Chicago in 1893. He showed a keen interest in affairs on this side of the Atlantic. He was the author of "Electrical Illumination," "Thames Bridges," Transportation Exhibits at the World's Columbian Exposition," etc.

William Lehnartz died at Los Angeles, Cal., July 16, aged 27 years. He was graduated from the University of Michigan in the mechanical engineering course with the class of 1900, and received the degree of A. M. from the same institution in 1901. He was a member of the Verein Deutscher Ingenieure and had been employed as a mechanical engineer by the Bucyrus Co. and also the Allis-Chalmers Co., of Milwaukee, Wis., with whom he was associated at the time of his death.

ENGINEERING SOCIETIES.

COMING MEETINGS.

THE NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 12-14. Annual Convention at Fabyan House, White Mountains, N. H. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC WORKS ASSOCIATION.
Sept. 14-15. Second Annual Meeting at Atlanta, Ga. Secy., W. H. Flint, Chattanooga, Tenn.

LEAGUE OF AMERICAN MUNICIPALITIES.
Sept. 26 to 28. Annual convention at Chicago, Ill. Secy., Jno. MacVicar, Des Moines, Ia.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 2 to 5. Annual Meeting at Birmingham, Ala. Secy., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 15 to 19. Annual Convention at Columbus, O. Secy., Bernard V. Swenson, 60 Wall St., New York City.

THE FOURTH ANNUAL CONFERENCE of the engineers of the U. S. Reclamation Service will be held at Boise, Idaho, Sept. 3 to 8. These conferences are for the purpose of giving the principal engineers of the Service a chance to discuss matters of administration and economics of work. Papers relating to the work of the Reclamation Service will also be read.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.—The society held its summer meeting Aug. 14 upon the Connecticut River aboard the steamer "Madeline." The start was made from Lyme station, on the east bank of the river, and the trip ended at Hartford, Conn. Before starting, the new bridge which the New York, New Haven & Hartford R. R. is building at Lyme, was inspected. A stop was made at Portland to view the famous old Portland quarries which have been worked continuously since before 1665. On arrival at Hartford the party landed at the new stone bridge which is now under construction.